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THE QUARTERLY REVIEW of BIOLOGY



THE TROPHIC NATURE OF THE PLANT-LIKE FLAGELLATES

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INTRODUCTION

THE Phytomastigophora, or plant-like flagellates, constitute an interesting group of borderline organisms. Recognized as Algae by botanists and as Protozoa by zoologists, their taxonomic status has long been disputed. Taxonomic compromises have been attempted. For example, Calkins (1933) has proposed the allocation of the chlorophyll-bearing species to the plant kingdom, retaining at the same time many of the colorless forms in Zoomastigophora. The advantages of such a disposition are debatable, since the effect would be the subdivision of a rather well defined group on the basis of inadequate morphological criteria.

The puzzling mixture of morphological characteristics in the Phytomastigophora is paralleled to some extent by certain physiological characteristics of these flagellates. Methods of nutrition range from holozoic in some colorless species to autotrophic (holophytic, or photoautotrophic) in certain of the chlorophyll-bearing types. Designation of a particular method of nutrition as characteristic of a

given species is sometimes arbitrary and may even be inaccurate. Both holophytic and holozoic types may carry on saprozoic nutrition, and combinations of photosynthesis and holozoic nutrition are known. Moreover, certain "holophytic" species have been grown in darkness, thus being forced to depend entirely upon saprozoic nutrition. Furthermore, recent investigations indicate that certain species of *Euglena*—previously considered typical plant-like flagellates—are not autotrophic, since they are apparently unable to multiply in the absence of amino acids or peptones in spite of their ability to carry on photosynthesis. The present situation indicates the need for further investigation of nutrition in the plant-like flagellates.

METHODS OF NUTRITION

In the older terminologies, methods of nutrition in Protozoa were classified as *autotrophic* (= holophytic), *saprozoic* and *holozoic*, the last two sometimes being recognized as different varieties of *heterotrophic* nutrition. In autotrophic nutrition the organisms carry on photosynthesis and are capable of continued growth

in a suitable inorganic medium. (The term *growth*, as used in the present discussion, refers to growth of populations and not to growth of individual cells.) The saprozoic types require organic compounds in solution, whereas holozoic organisms ingest solid food particles. The present tendency (e.g., Dusi, Lwoff, Pringsheim) is to introduce designations for various specialized types of nutrition. The following list represents a simplification of the terminologies introduced by several writers:

- I. *Phototrophic nutrition*: exhibited by chlorophyll-bearing species; energy of light is utilized in photosynthesis; some species appear to be obligate phototrophs. On the basis of the simplest possible nitrogen requirements in each case, phototrophic nutrition may be subdivided as follows:
 - (1) *Photoautotrophic nutrition*: characteristic of species which can grow in inorganic solutions; e.g., *Chlorogonium eucolorum*.
 - (2) *Photomesotrophic nutrition*: exhibited by species which can grow in media containing amino acids but not in inorganic media; e.g., *Euglena deses*.
 - (3) *Photomixotrophic nutrition*: characteristic of species capable of growth in peptone solutions but not in amino-acid media or inorganic solutions; e.g., *Euglena pisciformis*.
- II. *Chemoautotrophic nutrition*: described in certain bacteria capable of growth in inorganic media without utilizing energy of light; unknown in Protozoa.
- III. *Heterotrophic nutrition*: characteristic of colorless organisms, for which an organic carbon source is necessary in the absence of chlorophyll. Some chlorophyll-bearing species can be grown in darkness and may, in this sense, be considered facultative heterotrophs. On the basis of nitrogen requirements, heterotrophic nutrition may be subdivided as follows:
 - (1) *Heteroautotrophic nutrition*: utilization of inorganic compounds of nitrogen in the presence of an organic carbon source; e.g., *Polysoma uvula*.
 - (2) *Heteromesotrophic nutrition*: growth requirements may be satisfied by one or more amino acids as sources of nitrogen and carbon; growth is usually more vigorous with an

additional carbon source; e.g., *Polysommella caeca*.

- (3) *Heteromixotrophic nutrition*: characteristic of organisms which grow in peptone solutions but not in amino-acid media or in inorganic solutions; e.g., *Hyalogonium klebsii*. This type of nutrition is also exhibited by those holozoic Protozoa (ciliates, amoebae) which have been grown in pure cultures.

Photoautotrophic nutrition

In any attempt to demonstrate photoautotrophic nutrition, the species in question must be carried through a series of transfers in a suitable inorganic medium. This series must be long enough to eliminate, by serial dilution, any organic foods carried over from the original stock culture, since traces of protein derivatives may be adequate for growth. Thus, *Chilomonas paramecium* (Hall and Loefer, 1936) has been grown in a salt solution containing peptone in a concentration of 5×10^{-6} , and *Euglena anabaena* (Hall and Schoenborn, 1938) in peptone concentrations of approximately 2.5×10^{-6} grams per cubic centimeter. In both instances, lower concentrations failed to support growth. Hence, it seems that serial dilution of organic foods from the original stock cultures should reach 10^{-10} or higher if conclusions regarding the autotrophic nature of an organism are to be valid. Such technique obviously demands both chemical cleanliness of glassware and bacterial sterility of the cultures, and the pure culture method thus affords the only logical approach to the study of autotrophic nutrition. The procedures followed by several investigators have been described elsewhere (Hall, 1937).

If the criteria of bacteria-free cultures and successive transfers in inorganic media are applied to the available evidence, surprisingly few examples of photoautotrophic flagellates are to be recognized. For the orders Chrysomonadida, Heterochlorida, Cryptomonadida, Dinoflagellida and

Chloromonadida, there is as yet no admissible evidence bearing on the problem of autotrophic nutrition.

A number of investigations have been carried out with Euglenida but the evidence is inconclusive in some cases, since different workers have reached contradictory conclusions for the same species. Pringsheim (1912), Mainx (1928) and Dusi (1930, 1930a, 1933) have reported that *Euglena gracilis* is a facultative autotroph. Hutner (1936), however, failed to grow the Mainx strain in inorganic media, and suggested that the findings of his predecessors might have resulted from errors in technique. More recently, Hall and Schoenborn (1939) have carried the same strain of *E. gracilis* through eleven transfers in inorganic media. In the eleventh transfer the peptone carried over from the original stock culture had been diluted to less than 7×10^{-18} grams per cubic centimeter.

The case of *E. anabaena* is somewhat similar. Dusi (1930a), working with the Mainx strain, concluded that the species is not photoautotrophic. After additional investigation, however, Dusi (1933a) reversed this opinion. Later, Hutner (1936) failed in his attempts to grow the Mainx strain in inorganic media, and Hall and Schoenborn (1938) were likewise unsuccessful with certain media, including the one Dusi considered most suitable for the species. More recently, the writer (Hall, 1938) has carried *E. anabaena* through nine successive transfers in a medium not previously tried for this species. Since the peptone concentration has already been reduced to 1.7×10^{-15} grams per cubic centimeter, this evidence supports Dusi's (1933a) opinion.

The trophic nature of several other species of *Euglena* has also been investigated. *E. deses*, according to Mainx (1928), is photoautotrophic. On the

other hand, Dusi (1930, 1933a) and Hall and Schoenborn (1938) have been unable to agree with this conclusion. *E. viridis* was also considered photoautotrophic by Mainx, while Dusi (1936) has reported survival but no growth in inorganic media. Hall (1939), however, has grown the Mainx strain of this species for nine transfers in certain inorganic media, the calculated peptone concentration having been reduced to 1.9×10^{-14} . Mainx (1928) and Dusi (1930a, 1933a) have also disagreed on *E. pisciformis*, the latter concluding that the species is not autotrophic. Investigations in the writer's laboratory tend so far to support Dusi's conclusion. For *E. klebsii* and *E. stellata*, similar conclusions have been reached by Mainx and Dusi, and the photoautotrophic nature of these species is unquestioned. Mainx also reported that *Colacium vesiculosum*, *Euglena minima*, *E. mucosa* and *E. velata* are photoautotrophic. It should be pointed out, however, that Mainx did not subject his strains to successive transfers in inorganic media and that his best results were obtained when inorganic media were inoculated directly from stock cultures in creptone media; hence, growth may possibly have been dependent upon organic materials carried into the inorganic solutions. Even with such methods, *E. olivacea* and *E. velata* grew very slowly, while *E. rubra* and *Phacus pleuromectes* usually failed to grow at all in inorganic solutions.

Obviously, the trophic nature of the Euglenidae as a group is somewhat uncertain. It is not impossible that, in an order containing colorless saprozoic and holozoic types as well as chlorophyll-bearing species, some of the green forms may have evolved, or degenerated, toward the saprozoic method of nutrition. Hence, recognition of certain species as photoautotrophs and of *E. deses* and *E.*

pisciformis as photomesotroph and photometatroph, respectively, may accurately represent the situation.

On the other hand, explanations must be found for the conflicting reports on certain species. Several possible explanations are apparent. In the first place, it is probable that differences in formulae of the media may be responsible for some of the differences in results. For example, most investigators have used a salt concentration of not more than 2.0 grams per liter, whereas "medium B" of Hutner (1936), in actual use, contained approximately 5.0 grams. Another illustration is Hutner's addition of sodium acetate to an inorganic medium, while Dusi (1930, 1930a, 1933, 1933a) used acetate-free solutions. Furthermore, Hutner used an acetate concentration of not less than 0.3 per cent for *Ea. nabaena* and *E. gracilis*, whereas a concentration of 0.05 per cent appears to be optimal for *E. stellata* (Hall, 1937a).

However, differences in formulae were not responsible for the findings of Hall and Schoenborn (1938), who tried Dusi's best medium, as well as several others, for *E. anabaena* and still were unable to grow this flagellate in inorganic solutions. Contradictory results of this type might be explained on the following basis. It is possible that media used in these investigations may be prepared according to the same formulae and yet differ in their content of elements essential for growth. Thus, an essential element might be present in traces in one preparation of a salt and be lacking in another which had been purified to a higher degree. This possibility is supported by the fact that Hall and Schoenborn (1939) obtained growth of *E. gracilis* in certain media to which manganese had been added, while previous attempts with several media presumably manganese-free had proven negative. The

addition of manganese was suggested by earlier findings (Hall, 1937b) that this element accelerates growth of *E. anabaena* in organic and inorganic media. In addition to manganese, calcium may be important in autotrophic nutrition, since Dusi (1933a) found it necessary to add calcium to his media for best growth of *E. stellata*, and Hall and Schoenborn (1939) have obtained good results with *E. gracilis* in a medium containing calcium and manganese. The same calcium-manganese medium has also been used by Hall (1938, 1939) for *E. anabaena* and *E. viridis*.

The present lack of information concerning the inorganic substances essential to growth of Euglenidae and the optimal concentrations of such substances makes it difficult to conclude that any species is actually incapable of autotrophic nutrition. Growth requirements of these flagellates may be more exacting than formerly supposed, and negative results with any one species may mean only that the growth requirements have not yet been satisfied. Such species as *E. deses* and *E. pisciformis* should be investigated further with this possibility in mind before they are classified definitely as photomesotrophs or photometatrophs. However, until contradictory evidence is forthcoming, it must be admitted that at least some species of *Euglena* may not be photoautotrophic.

In the order Phytomonadida there is no such disagreement concerning photoautotrophic nutrition. Lwoff and Lwoff (1929) and Lwoff (1932) reported that both *Cblamydomonas agloiformis* and *Haemrococcus pluvialis* are photoautotrophic. Mainx (1928) had reached the same conclusion for *Cblamydomonas umbonata*, although he did not use the technique of successive transfers. Loefer (1934) demonstrated that *Cblorogonium elongatum* and *C. euchlorum* are autotrophic. These obser-

uations on *C. eucolorum* were subsequently confirmed by Hall and Schoenborn (1938), who found that this species grew well in media which did not support growth of *Euglena anabaena* and *E. deses*. Investigations on Phytomonadida might well be extended to additional genera and species for the accumulation of more evidence, but it seems likely that photoautotrophic nutrition may prove to be a general characteristic of the chlorophyll-bearing species in this order.

Photomesotrophic and photometatrophic nutrition

These terms are applied to combinations of photosynthesis and saprozoic nutrition, as defined above, and may be exhibited by chlorophyll-bearing species grown in light in media containing suitable organic food. Certain species, e.g., *Euglena deses* (Dusi, 1933a), appear to be obligate photomesotrophs—that is, photomesotrophic nutrition is the simplest possible type; others (e.g., *E. pisciformis*) may be considered obligate photometatrophs. So far, investigations with pure cultures have been carried out only on certain Euglenidae and Phytomonadida.

The ability of chlorophyll-bearing species to carry on photometatrophic nutrition under suitable conditions appears to be widespread, according to reports of several workers, particularly Pringsheim, and the writer's own experience with stock cultures. The list of species which have been grown in peptone solutions includes more than a dozen Euglenidae and approximately 30 Phytomonadida. Loefer (1935a) found that, for *Chlorogonium elongatum* and *C. eucolorum*, a peptone of high amino-nitrogen content was most satisfactory, while casein and gelatin were much less satisfactory. Hutner (1936) reported that growth of *Euglena anabaena* is not supported by gelatin or

casein, while Hall (1938) has since carried the same strain through 16 successive transfers in gelatin media for a period of 14 months.

Nitrogen requirements in photomesotrophic nutrition of Euglenidae have been the subject of a few investigations. Ternetz (1912) found that glycocoll, alanine and asparagin were good nitrogen sources for *E. gracilis*, and Pringsheim (1912) reported slow growth of the same species on amino-acid-agar media. Mainx (1928), on the other hand, obtained negative results in his attempts to grow several species of *Euglena* on single amino acids and artificial mixtures, although natural mixtures of amino acids, such as completely digested peptones, were satisfactory. Mainx suggested, therefore, that his preparations of amino acids might have contained traces of heavy metals in toxic concentrations. This suggestion is in accord with Dusi's (1931, 1933, 1933a) later findings that single amino acids will serve as sources of nitrogen for *E. anabaena* var. *minor*, *E. deses*, *E. gracilis*, *E. klebsii*, and *E. stellata*, but not for *E. pisciformis*. Thus, *E. pisciformis* is to be considered an obligate photometatroph, while the others are capable of photomesotrophic nutrition. Dusi's findings are particularly interesting in that they indicate specific differences in growth requirements. Thus, glycocoll did not support growth of *E. deses*, and yet was adequate for the other four species; phenylalanine gave negative results for *E. deses* and *E. klebsii* but supported growth of the other three; serine was adequate for growth of all save *E. anabaena*, and aspartic acid for all except *E. klebsii*. Analogous differences were observed for other amino acids. More recently, Dusi (1936) has obtained poor growth of *E. viridis* through three transfers in an asparagin medium, and has suggested that a complex source of nitrogen

may be essential for continued growth of the species. Hence, the ability of *E. viridis* to carry on photomesotrophic nutrition is uncertain. Hutner (1936) has been unsuccessful in attempts to grow *E. anabaena* and *E. gracilis* in media containing single amino acids or mixtures of several. On the other hand, the writer (Hall, 1938) has been more successful with *E. anabaena*, which is growing at present in the ninth transfers in glycocoll and asparagin media. An explanation for Hutner's failures is not yet available. At present, it seems probable that the majority of the Euglenidae will prove to be capable of carrying on photomesotrophic nutrition, although, in the absence of evidence to the contrary, *E. pisciformis* must be considered an obligate photometatroph.

For the Phytomonadida, the available evidence indicates that the ability to carry on photomesotrophic nutrition is characteristic of the chlorophyll-bearing species. Lwoff (1932) reported that asparagin, glycocoll and cystine each supported growth of *Chlamydomonas agloiformis* and *Haematococcus pluvialis*. Loefer (1932, 1935a) has observed, in *Chlorogonium elongatum* and *C. euehlorum*, acceleration of growth by glycocoll, valine, leucine, phenylalanine, tyrosine and asparagin. Whether each of these will support growth through successive transfers has not been determined.

Growth of chlorophyll-bearing species in amino-acid media (photomesotrophic nutrition) and in peptone media (photometatrophic nutrition) is accelerated by the addition of a suitable carbon compound.

Under both conditions, Lwoff (1932) has described such effects of sodium acetate for *Chlamydomonas agloiformis*, *Haematococcus pluvialis* and *Euglena gracilis*. Other workers have reported similar observations on *E. gracilis* (Dusi, 1933; Provasoli, 1938) and *Euglena* sp. (Provasoli, 1938). The effects of several salts of organic acids on growth of *E. gracilis* have been com-

pared quantitatively by Jahn (1935b), and the effects of different concentrations of acetate on growth of *E. stellata* have been determined by Hall (1937a). Growth of *E. gracilis* (Jahn, 1935) is accelerated also by soluble starch and, under certain conditions, by several other carbohydrates. In addition, ethyl alcohol (Loefer and Hall, 1936) accelerates growth of *E. desus* and *E. gracilis*. For *Chlorogonium elongatum* and *C. euehlorum*, Loefer (1933, 1935) has reported marked acceleration of growth by levulose, galactose, maltose and lactose, and less noticeable effects by rhamnose, dextrose, xylose and arabinose. In addition to these more detailed observations, the writer has noted, in a comparison of various stock peptone media, that sodium acetate accelerates growth of the following species: *Euglena anabaena*, *E. desus*, *E. gracilis*, *E. klebsii*, *E. pisciformis*, *E. stellata*, *E. viridis* (Euglenidae); and *Chlamydomonas agloiformis*, *C. dorsoventralis*, *C. oblonga*, *C. oviformis*, *C. proteus*, *C. pulchra*, *C. subtilis*, *C. umbonata*, *Chlorogonium elongatum*, *C. euehlorum*, *Haematococcus pluvialis*, *Labomonas piriformis* (Phytomonadida).

Heteroautotrophic nutrition

The term *heteroautotrophic* has been applied by Pringsheim (1937b) to flagellates which can utilize inorganic nitrogen (e.g., ammonium salts) in the presence of an organic source of carbon, such as sodium acetate. The case of *Chilomonas paramecium* is in dispute. Mast and Pace (1933) reported that this species grows in a medium containing ammonium chloride as the source of nitrogen. Loefer (1934), on the other hand, was unsuccessful in attempts to grow the flagellate in inorganic media, and Pringsheim (1935) likewise was unable to substantiate the findings of Mast and Pace. Later, Hall and Loefer (1936) tried "solution D" of Mast and Pace as well as several other media, again with negative results. These conflicting results raise the possibility that different strains of a given species may differ in trophic nature. Or such differences in results might depend upon chemical differences in media not indicated in published formulae, as suggested above for Euglenidae.

A more firmly established case of hetero-

autotrophic nutrition is that of *Polytoma uvella*. Pringsheim (1921) reported that, as nitrogen sources, ammonium salts in the presence of acetate are just as satisfactory as amino acids. Comparable results have been obtained more recently by Lwoff (1929, 1931, 1932), and additional observations have since been published by Pringsheim (1937a).

Heteromesotrophic and heterometatrophic nutrition

These types of nutrition involve utilization of organic compounds of nitrogen—amino acids in the former, and more complex compounds in the latter. Such methods of nutrition are characteristic of Phytomastigophora without chromatophores, and may in some cases be imposed upon chlorophyll-bearing species by maintaining cultures in darkness. This change from phototrophic to heterotrophic nutrition may, in the green species, be correlated with physiological modifications not yet understood. Thus, Elliott (1937) has shown that growth of *E. gracilis* in darkness is not accelerated by several plant hormones, whereas marked effects are to be observed in light. These same plant hormones produce no effect on growth of the colorless euglenoid, *Khawkinia halli* (Elliott, 1938). Hence, with respect to action of the plant hormones, *E. gracilis* in darkness is similar to a related colorless species. Jahn (1935b) has found that sodium succinate, in certain concentrations, accelerates growth of *E. gracilis* in darkness but is slightly toxic to the flagellates in light. Also, relatively greater acceleration of growth was produced by butyrate, acetate and lactate in darkness than in light. The observations of Hall (1937a) on *E. stellata* are comparable, since growth of this flagellate in light was decreased by the higher concentrations of

sodium acetate which accelerated growth in darkness.

In the writer's laboratory, the following species have been grown successfully in various peptone media (heterometatrophic nutrition)

Chilomonas paramecium (strain J-L), *Astasia longa* (Pringsheim strain), *Astasia quartana* (Pringsheim strain), *Astasia* sp. (strain J), a colorless strain of *Colacium vesiculosum*, *Khawkinia halli* (strain J), *Polytomella caeca* (Pringsheim strain), *Polytoma uvella* (Pringsheim strain). To this list may be added *Hyalogonium klebsii* (Pringsheim, 1937), *Polytoma caudatum* var. *astigmata* (Lwoff and Provasoli, 1935), *Polytomella agilis* (Lwoff, 1935a), *Chilomonas oblonga* (Pringsheim, 1937c), *Polytoma ocellatum* (Pringsheim, 1937c), *Astasia chattani* (Lwoff and Dusi, 1934, 1936), and a colorless strain of *Euglena mesnili* (Lwoff and Dusi, 1935).

It thus appears that all of the colorless Phytomastigophora so far investigated are capable of carrying on heterometatrophic nutrition.

Only a few detailed observations on nitrogen sources in heterometatrophic nutrition have been completed. Loefer (1932, 1935a) has compared a series of different peptones and proteins as food for *Chilomonas paramecium*. Most rapid growth was observed in a peptone of comparatively high amino-nitrogen content, and relatively slow growth in unhydrolyzed proteins such as casein and gelatin. Several peptones have also been compared as to their availability for *Hyalogonium klebsii* (Pringsheim, 1937), and for *Polytoma uvella* and *Polytomella caeca* (Pringsheim, 1937a).

Heteromesotrophic nutrition has been investigated in several species. Mast and Pace (1933) reported that glyocoll is adequate for growth of *Chilomonas paramecium*, and this was later confirmed by Hall and Loefer (1936). Mainx (1928) was unable to grow *Astasia ocellata* on single amino acids or artificial mixtures, and the ability of any species of *Astasia* to carry

on heteromesotrophic nutrition is uncertain. Pringsheim (1921) found that glycocoll and certain other amino acids support only slow growth of *Polytoma uvella*, while a medium containing glycocoll and sodium acetate is quite satisfactory. According to Lwoff and Dusi (1934), this species also grows very poorly in an asparagin medium but quite vigorously with an additional carbon source such as sodium acetate. *Polytomella caeca* (Pringsheim, 1935, 1937a) likewise grows in amino-acid media containing sodium acetate, while both *Polytomella agilis* (Lwoff, 1935a) and *Polytoma caudatum* var. *astigmata* (Lwoff and Provasoli, 1935) grow slowly in asparagin media but rapidly with added acetate. *Polytoma* and *Polytomella* are thus able to carry on heteromesotrophic nutrition. *Hyalogonium klebsii* (Pringsheim, 1937), on the other hand, is an obligate heterometatroph which requires peptones for growth.

The effects of added carbon sources on growth of several colorless species have been determined. Loefer (1935) found that, for *Chilomonas paramecium*, marked acceleration of growth was produced by dextrin, and less noticeable effects by levulose, galactose, lactose, maltose, arabinose and dextrose. Among the salts of various fatty acids (Loefer, 1933, 1935), acetate, butyrate, valerate and propionate—in descending order—were most effective. Similar effects of acetate have been reported for other strains of *C. paramecium* (Lwoff and Dusi, 1934; Pringsheim, 1935, 1937c), and growth of *C. oblonga* is accelerated, in addition, by salts of butyric, isobutyric, propionic, valeric, pyruvic and succinic acids. *Chilomonas* thus appears to utilize several carbohydrates and organic acids as sources of carbon. Fermentation of carbohydrates, however, has not yet been demonstrated, and Loefer (1937) has obtained no evidence that *C.*

paramecium utilizes appreciable quantities of dextrose over short periods of incubation.

Among the colorless Euglenidae, growth of *Astasia chattoni* (Lwoff and Dusi, 1934) is accelerated by acetate, lactate and pyruvate, and also (according to Lwoff and Dusi, 1936) by propionate, butyrate, caproate and valerate. Pringsheim (1937c) has reported, for *A. longa*, acceleration of growth by acetate, propionate, butyrate, isobutyrate, malate and succinate, while growth of *A. quartana* is affected by only the first three salts. For the last species, however, Provasoli (1938) has obtained acceleration of growth with several salts which gave negative results in Pringsheim's experiments.

Similar effects have been noted in some of the colorless Phytomonadida. Growth of *Polytoma uvella* (Pringsheim, 1937a, c) is increased by acetate, butyrate, lactate and succinate and, according to Lwoff and Dusi (1934), also by starch; one of Pringsheim's (1937c) strains of *P. ocellatum*, by acetate, butyrate, isobutyrate, valerate, malate, lactate and succinate; a second strain (Pringsheim, 1937c) of the same species, only by acetate, propionate and isobutyrate; *P. caudatum* var. *astigmata* (Lwoff and Provasoli, 1935), by acetate, butyrate, pyruvate and starch; *Polytomella caeca* (Pringsheim, 1937a, c), by acetate, butyrate, propionate, valerate, isobutyrate, lactate and succinate; *P. agilis* (Lwoff, 1935a), by acetate, butyrate, propionate, valerate, caproate, isobutyrate and starch; *Hyalogonium klebsii* (Pringsheim, 1937, 1937c), only by acetate and succinate. Such observations point out interesting differences in the variety of carbon compounds utilized by colorless Phytomonadida. Such differences are exhibited not only by different species, but also by different strains of the same species (Pringsheim, 1937c).

In darkness the chlorophyll-bearing Phytomastigophora must, if they continue to grow, carry on either heteromesotrophic or heterometatrophic nutrition. Heterometatrophic nutrition in darkness has been reported for several Phytomonadida: *Cblamydomonas agloëformis* (Lwoff and Lwoff, 1929; Lwoff, 1932), *Chlorogonium elongatum* (Loefer, 1934), *C. euehlorum* (Loefer, 1934; Lwoff and Dusi, 1935a), *Haematococcus pluvialis* (Lwoff and Lwoff, 1929; Lwoff, 1932). In all cases growth in darkness is accelerated by the addition of acetate, or some other suitable carbon compound, to the medium. Loefer (1935) has compared the effects of eleven carbohydrates and of several fatty acids on growth of *C. elongatum* and *C. euehlorum*. Of the carbohydrates, levulose was most effective, and the other results were similar to those for cultures grown in light. Of the fatty acid salts, growth was accelerated—in descending order—by acetate, butyrate, valerate and isobutyrate. Lwoff and Dusi (1935a) reported that, for *C. euehlorum*, acetate, pyruvate, and soluble starch were most effective of a number of fatty acid salts and carbohydrates.

The ability of Euglenidae to carry on heteromesotrophic nutrition in darkness is yet to be demonstrated. However, heterometatrophic nutrition in darkness has been described for *Euglena mesnili* by Lwoff and Dusi (1935), for *Euglena* sp. by Provasoli (1938), and for *E. gracilis* by Zumstein (1899), Pringsheim (1912), Ternetz (1912), Mainx (1928), Lwoff and Dusi (1929, 1934), Jahn (1935a, b). Much heavier growth was noted by Lwoff and Dusi when sodium acetate was added to the medium. Similar results were obtained by Jahn, who has compared quantitatively the effects of various organic acids on growth of *E. gracilis*. On the other hand, some of the Euglenidae appear to be incapable of continued

growth in darkness. Thus, Dusi (1933a) has reported that *E. anabaena* var. *minor*, *E. deses*, *E. klebsii*, *E. pisciformis* and *E. stellata* will not grow in darkness even with such a carbon source as sodium acetate. Hall (1933) also observed that growth of *E. anabaena* in peptone media is very slow in darkness, while that of *E. deses* is insignificant. In the case of *E. anabaena* (Hall, 1934) significant acceleration of growth in darkness is produced by the addition of dextrose, levulose or maltose to a peptone medium, while growth in other carbohydrate media is not appreciably greater than that in the controls. No attempt was made to carry the strain through a series of transfers in darkness. *E. stellata* (Hall, 1936), however, has shown growth through several transfers in a medium containing peptone and sodium acetate.

DISCUSSION

In the present survey it has been pointed out that certain of the chlorophyll-bearing Phytomonadida are capable of carrying on photoautotrophic nutrition under suitable conditions and, so far as the evidence extends, are all capable of heteromesotrophic nutrition when grown in darkness. This group includes all those species which have been investigated adequately: *Cblamydomonas agloëformis*, *Chlorogonium elongatum*, *C. euehlorum*, *Haematococcus pluvialis*. While the accumulation of additional evidence is desirable, it seems probable that photoautotrophic nutrition will prove to be characteristic of chlorophyll-bearing Phytomonadida. This assumption is in accord with the current generalization that the chlorophyll-bearing members of this order are the most "plant-like" of all the Phytomastigophora.

The colorless Phytomonadida, however, show interesting differences in growth requirements. *Polytoma uvella* may carry

on heteroautotrophic nutrition. On the other hand, *P. caudatum* var. *astigmata* and *Polytomella caeca* appear to have lost this ability, and must be considered heteromesotrophs. *Hyalogonium klebsii* stands apart as an obligate heterometatroph which is dependent upon peptones. Even in the Phytomonadida, therefore, there is an apparent trend toward methods of nutrition characteristic of the more "animal-like" Protozoa.

The trophic nature of the chlorophyll-bearing Euglenidae does not show the uniformity noted in the green Phytomonadida. In the light of present evidence, *E. gracilis*, *E. klebsii* and *E. stellata* may be recognized as photoautotrophs. The autotrophic status of *E. anabaena* is somewhat less certain, while the trophic nature of *E. viridis* is yet in dispute. *E. deses* and *E. pisciformis* appear to be incapable of growth in inorganic media. *E. deses* has been grown on amino acids, and may be considered photomesotrophic, whereas *E. pisciformis* apparently requires peptones and must be classified as an obligate photometatroph. Additional species investigated by Mainx (1928) have not been tested by the method of successive transfers.

In darkness, *E. gracilis* can be grown in peptone media and, in that sense, is no longer dependent upon photosynthesis. Similarly, *E. mesnili* has been grown in darkness and a strain without chlorophyll also has been maintained in the laboratory by Lwoff and Dusi. Certain species, however, appear to be dependent upon light. Thus there is no evidence that *E. anabaena*, *E. deses*, *E. klebsii* and *E. pisciformis* are capable of continued growth in darkness. Hence, it is necessary to recognize, within the genus *Euglena*, photoautotrophic species, photomesotrophic species, and photometatrophic species; obligate phototrophs, which are incapable of growth in

darkness, and facultative heterotrophs, which can be grown indefinitely in darkness. The evolutionary trend, away from the primitive autotrophic condition, appears to be well marked in the green Euglenidae, and such physiological specialization is not surprising in an order which has evolved free-living saprozoic and holozoic types as well as several parasitic species.

The need for additional investigations on the nutrition of plant-like flagellates is obvious. Only with more detailed information will it be possible to decide whether certain species are photoautotrophic or have really lost this primitive characteristic. Such information may also explain the differences in results obtained by various workers. Investigations have been limited so far to the Euglenida, Phytomonadida and a few Cryptomonadida, and none of the holozoic members of these groups has yet been grown in pure culture. The other orders are not yet represented by bacteria-free strains. The application of the pure-culture technique to these orders and to additional species of Cryptomonadida, Euglenida and Phytomonadida should afford solutions to many interesting problems. Evidence already accumulated indicates that the evolution of colorless flagellates has been accompanied by fundamental changes in physiological characteristics, and an understanding of such modifications is dependent upon more widely extended investigations. The little information now available suggests that some of the plant-like flagellates approach, in their growth requirements, the Zoomastigophora, Ciliata and Amoe-bida which have been established in pure cultures. Investigations in this field may eventually throw some light on the evolution of other groups of Protozoa from the plant-like flagellates.

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ADOLESCENT STERILITY

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"Where Nature indicates a fact, we do well to attend to her instruction."

J. M. Waddy, 1846.

ADOLESCENCE (Middle English *ad*, to, + *olescere*, the inceptive form of *olere* [?], grow) means literally the state of growing. Specifically the term is applied to that period of life which falls between puberty and the full development of the body; a period generally assumed to extend in man from about 13 to 23 years of age. Naturally a period of such importance has attracted many students, as the very considerable literature devoted to the study of adolescence attests. In recent years the most significant contribution to our understanding of the biology of adolescence has come from the field of endocrinology. A number of the endocrine glands have been shown to represent the fundamental agents in the determination and regulation of the processes of development, particularly during the period of adolescence. And in this connexion the findings of endocrinologists make necessary the revision of our conceptions of the phases of the developmental period of adolescence. Puberty, menarche, maturity, and adolescence are terms which today are all too loosely used, yet the phenomena which they embrace are capable of precise and fairly exact definition. Such definitions will be attempted in the course of this paper.

As is well known, the arrival of puberty is generally regarded as a condition which, in the female, is marked by the appearance of the first menstruation, or the menarche; this event is practically universally taken to be coincident with the establishment of the capacity to reproduce. The root of the word puberty, *pu*, actually means *to beget*. Thus, puberty, menarche, and the development of the capacity to reproduce are regarded as synchronous 'events' which may be referred to by terms of synonymous and assumed equal value. Certainly every dictionary makes the identity of this triad complete, and almost all contemporary writers, with very few exceptions, do so. Puberty is regarded as a moment in time determined by the arrival of the menarche, an event which is in turn taken to signalize the development of the capacity to reproduce.

Modern research on the reproductive physiology and growth of mammals such as the mouse, rat, macaque, chimpanzee, and man, very strongly suggests that puberty, menarche, and the development or attainment of the capacity to reproduce are phenomena by no means so closely associated with one another as has hitherto been supposed, but rather that they are distinctly separable phenomena both in time and in character. It now

appears fairly certain that puberty itself properly represents an extended process of development, rather than an event or a moment in time; and that it is during the progress of this developmental process that menarche is gradually established, and reproductive capacity only very rarely. Puberty does not mark a stage of development, but represents more clearly a *phase* of development. Menarche represents a stage in that particular phase of development, the stage of beginning (anovulatory) ovarian activity. The capacity for reproduction generally follows appreciably later. The attainment of this capacity marks the termination of the period of puberty and the initiation of the period of nubility which, in the human species, terminates in the period of maturity only after the lapse of some years in time, and much increase in size and differentiation of various organs.

The interval between the establishment of menarche, or the so-called arrival of puberty, and the establishment of the capacity to reproduce, appears to be a normal feature of the developmental physiology of all the lower mammals thus far investigated. In the present paper it is proposed to inquire into the existence of such a period of adolescent sterility in the human female. The way for such a study has already been prepared by the writings of C. G. Hartman who, among contemporary students of reproductive physiology, was the first to suggest that the human adolescent female was probably characterized by a period of relative sterility during the first part of this phase of her development. Himes (57), Zuckerman (146), Mills and Ogle (78), Schultz and Snyder (111), Ashley-Montagu (6, 7, 8, 9), Engle (36), Mikulicz-Radecki and Kausch (149), Greulich (43), Shuttleworth (115), and Pearl (150), have all recently

referred to this phenomenon with special reference to its applicability to the human species, so that the idea of the possible existence of such a period of adolescent sterility in man already enjoys a certain currency.

In recent years the first observers to draw attention to the phenomenon of the infertility of adolescent human females have been ethnologists.

Working in the field ethnologists have more than once been puzzled by the fact that in the societies studied by them the unmarried post-pubertal females, despite free and frequent intercourse with mature males, rarely become pregnant or bear children. Thus, for example, in 1926 Rivers (105) remarked in connection with the Eddystone Islanders of Melanesia studied by Hocart and himself that:

the very free relations existing before marriage might have been expected to lead to the birth of many children and to the existence of definite regulations for assigning such children to their proper place in society. Such births seemed, however, to be extremely rare, and in the whole of the pedigrees collected by us only one such case was given, and that many generations ago. We did not hear of any such birth either during our visit or in recent times; and so far as we know there was no one on this island who was the child of premarital intercourse. It was said that such births occurred, however, though no actual recent instances could be given.

Rivers goes on to say that "It is quite certain that births before marriage were very rare and two causes were given to account for this, abortion and a process resembling the other magico-religious rites of the island, called *egoro*, meaning 'barrenness,' which is believed to prevent conception."

Where information was available it appeared that women produced abortion by mechanical means, or by the process of rubbing a certain leaf, which had previously been heated, over the belly, and

finally by holding four leaves of another variety beneath the vulva, when, it was said, the child would 'come out.'

From Rivers' description of an *egoro* rite, the details of which need not be discussed here, it is perfectly clear that the rite is a purely magical one, and can have had no possible physical effect upon the woman. This becomes even more clear when we learn that the rite is believed to be quite as efficacious in producing sterility in the woman when it is performed upon her husband alone! Rivers does to some extent recognize the magical nature of the rite, but he nonetheless considers it quite possible that the concoctions used may actually produce some pathological condition of the uterus in the woman. This, however, is pure assumption and as an explanation of the condition of infertility among the unmarried women will manifestly not do; for it is obvious that a fairly large proportion of the Eddystone Islanders must be fecund, and that the rarity of births among the unmarried is, at least in part, due to the fact that though there may have been much intercourse, relatively few pregnancies have resulted therefrom.

In 1929 among the Trobriand Islanders of North-Western Melanesia Malinowski (71), observed that:

... it is very remarkable to note that illegitimate children very rare. The girls seem to remain sterile throughout their period of licence, which begins when they are small children and continues until they marry; when they are married they conceive and breed, sometimes quite prolifically. . . . I was able to find roughly a dozen illegitimate children recorded genealogically in the Trobriands, or about one per cent. . . .

Thus we are faced with the question: Why are there so few illegitimate children? On this subject I can only speak tentatively, and I feel that my information is perhaps not quite as full as it might have been, had I concentrated more attention upon it. One thing I can say with complete confidence: no preventive means of any description are known nor the

slightest idea of them entertained. This, of course, is quite natural. Since the procreative power of seminal fluid is not known, since it is considered not only innocuous but beneficial, there is no reason why the natives should interfere with its free arrival into the parts which it is meant to lubricate. Indeed, any suggestion of neo-Malthusian appliances makes them shudder or laugh according to their mood or temperament. They never practise *coitus interruptus*, and still less have any notion about chemical or mechanical preventives.

But though I am quite certain on this point, I cannot speak with the same conviction about abortion, though probably it is not practised to any large extent. . . .

So the problem remains. Can there be any physiological law which makes conception less likely when women begin their sexual life young, lead it indefatigably, and mix their lovers freely?

There has been some question concerning the accuracy of Malinowski's observations (103), but it has recently been independently established that these observations are in all particulars correct and confirmable (10, 104).

A very illuminating account of conditions prevailing among the natives of Wogeo, one of the most northerly of the Schouten Islands in the territory of New Guinea, has recently been given by Hogbin (58). Among the natives of this island sexual life does not begin until about the age of sixteen or seventeen years, or even later, whenafter it is particularly free. Hogbin wrote in 1935:

Single girls do sometimes have children, but illegitimacy is not nearly so common as one might have expected. Just why this is so it is impossible to say. Professor Malinowski, it will be remembered, found the same situation in the Trobriands. I observed one fact that bears directly on the problem, namely that it is extremely rare for women to have children until they are, I judge, more than 21 years of age, by which time most of them are safely married. I have noticed that even when a girl is married directly after her first menstruation, which does not regularly take place until almost certainly after the seventeenth year, it is most unusual for her to have a child for several years. One Dap girl had a child

within about eighteen months of her first menstruation—fortunately for herself she was married—and this was so unusual that she was described as a coconut putting forth a shoot before it had fallen from the parent tree. The comments on this girl, in fact, brought the whole matter to my notice.

Although the ages which Hogbin gives are admittedly only approximate, it was possible to check them fairly closely by reference to certain historic events known both to the investigator and to the islanders. It may appear to some that seventeen is rather a late age for the appearance of the first menstruation, especially in the Tropics, but the fact is that both the earliest (106) and the latest reliable evidence (25, 79), indicates very strongly that menarche generally occurs later among girls living in the Tropics than among those living in cooler climes.

In connexion with Melanesian peoples generally the investigations of Reche (101) on the Matupi of New Pomerania are of great interest. Reche reported in 1910 that among the Matupi no girl who had not yet arrived at the age of seventeen had menstruated.

From Hogbin's account it is clear that among the Dap of Wogeo despite frequent intercourse from menarche onwards a girl does not normally conceive until several years have elapsed; not even when she marries early. Among this people there can be no objection to a recently married woman giving birth to a child, but this is so unusual a phenomenon that it has given rise to the belief that it is not a normal thing for a young adolescent married woman to be able to bear children, and certainly not normal in an unmarried woman. In this belief these natives show themselves far in advance of the Western world, for their belief reflects the possession of knowledge based upon observation which, owing to a fortunate pattern of conditions which does not exist among

ourselves, enabled them to arrive at a knowledge of facts which were not understood elsewhere in the world until quite recently.

McLaren (76), who from 1911 to 1919 lived among the Australian blacks at Simpson's Bay, Cape York, in an extraordinarily interesting book recounting his experiences, quite in passing makes the following remarks:

Freely and without concealment the unmarried girls gave themselves to the young men of the tribe and to visitors from other tribes, sometimes in exchange for a coveted article of ornament or use, but oftener because such acts were to them as natural as eating or sleeping.

... But because of their knowledge of the abortive qualities of herbs and the like, illegitimate children were extremely rare. In all my eight years at Cape York they happened only twice, and in each case the girls were saved from being speared to death by the fact that their babies were born dead and undeveloped.

Finally Harrisson in a recent book about the natives of the New Hebrides notes of the North-West Malekulese: "Very rarely a child is born to an unmarried woman. Girls are married young." (50)

Such reports (see also those given in subsequent pages) raise a number of questions. What can be the explanation of this apparent infertility of the adolescent female in these simpler societies? Surreptitious abortion possibly, which escapes the inquiring attention of the anthropologist? This is possible, but there is absolutely no evidence that any of the infertile girls of these societies ever resorted to such a practice. Contraception? Clearly not among the Trobriand Islanders who have no understanding of the relation between intercourse and conception. And what of the abortive properties of the herbs used by the people described by McLaren, and the contraceptive properties of those used by the Eddystone Islanders described by Rivers? The evidence has recently been carefully examined by Himes and it

is his considered opinion that none of those herbs which have thus far been investigated for such properties can possibly have the effect which has been attributed to them (57). Early and indefatigable sexual life? There is no evidence that early and indefatigable sexual life produces a condition of adolescent sterility. On the other hand, the evidence available for those simpler peoples among whom sexual life commences at a very early age shows that they are neither more nor less sterile than those peoples among whom sexual life is begun late. It is to be remembered that Hogbin's natives did not commence active sexual life until they were seventeen years of age, yet they remained sterile for several years thereafter. It would indeed be very surprising to discover both licentiousness and abstinence producing the same effect. Free mixing of lovers? It has been said that prostitutes are sterile because they mix their lovers so often. But are prostitutes sterile? Or perhaps it may be more justly inquired: Are they sterile for this reason? Their fertility is without doubt low, but this is surely due, among other things, to the preventive measures which they take, and to the injurious effects of venereal and other disease from which they so frequently suffer. What other explanation then can there be for the infertility of these promiscuous adolescent girls? Is the adolescent infertility of these girls due to a natural or normal state of relative sterility characteristic of all normal human females at this period of their development, and perhaps also of all adolescent animals? Or is the phenomenon merely limited to the adolescent females of simpler societies? Finally, is it not possible that the phenomenon is a purely specious one?

To return an answer to these questions is the purpose of the present paper.

Certain terms which will be frequently used in the following pages may be conveniently defined here according to the definitions adopted by the Population Association of America (4):

Fecundity: The physiological capacity to participate in reproduction.

Sterility (or infecundity): The lack of physiological capacity to participate in reproduction.

Fecund: Having fecundity.

Sterile (or Infecund): Lacking fecundity.

Fertility: Fecundity expressed in performance and therefore measurable.

Infertility: Absence of fertility; synonymous with childlessness.

Fertile: Expressing fertility.

Infertile: Manifesting infertility; synonymous with childless.

LOWER MAMMALS

In an experiment reported in 1930 by Mirskaia and Crew (80) on 100 female mice which were mated at first oestrous, pregnancy followed in only 24 cases; 11 pregnancies occurring among the 58 coloured (19.5 per cent) and 13 among the 42 albino (30.9 per cent) mice. When, however, these same mice were three to six months old they exhibited a fertility ratio, i.e. the percentage of pregnancies following matings, of 80-90 per cent. Yet at first oestrous, or puberty, only 24 per cent of matings resulted in pregnancy.

Puberty in the mouse is defined by Mirskaia and Crew as "that stage of individual development characterized by the ability to elaborate functional gametes, and by the physical ability to, and desire to, play the appropriate rôle in mating" (81).

The authors write further:

"A review of the facts presented in this paper permits us to attempt a definition of maturity. It is manifest that puberty does not imply maturity of the individual, for when puberty is attained, neither the sex equipment nor the individual are full grown. We suggest that maturity is that stage of individual development which is characterised by the exhibition

of the maximum fertility ratio with reference to the conditions of husbandry that are present, and in the case of the female by the ability to produce viable offspring and to rear them. Litter size is not a criterion of maturity, for though it can be shown that in a population litter size increases with the chronological order of the pregnancy up to a maximum, it is as possible to obtain a litter of nine in a pregnancy following a first oestrous as to obtain a litter of two in a six months old animal. In our stock maturity is reached by the 3rd month of life.

"Puberty marks the completion of those processes of development which equip the individual for fruitful mating; maturity marks the completion of those processes of development which equip the individual for efficient reproduction. The two are distinct in time, for puberty is reached long before maturity is attained. This being so it can be understood that pregnancy is possible at and after the first oestrous, but that before maturity is reached such pregnancy will commonly be fruitless or dangerous. It is only when maturity is reached that pregnancy is uneventful. The causes of different rates of development leading to puberty and maturity respectively, and exhibited by different individuals, remains to be determined. It is seen from the tables that some individuals are mature at the time of puberty whilst others do not attain maturity until long afterwards" (p. 58).

These observations are worth discussing here in some detail.

In the first place it is to be noted that the number of pregnancies following upon first mating at the first oestrous exceeded by 11.4 per cent in the albino mice the number of pregnancies in the coloured mice. No explanation is offered by the authors for this phenomenon. Since the nutritional and environmental factors were the same for both breeds of mice, the suggestion is ventured that a genetic difference in the rate of development of the two breeds is probably responsible for the difference in the expression of fecundity; the albino reaching a higher fecundity potential at first oestrous than the coloured mice. This seems likely enough, but the suggestion requires to be experimentally tested. There is every reason to believe that the rates of development of an

organ or system of organs of an animal are genetically determined, and that under similar, or even dissimilar conditions (within certain limits), animals of the same genetic stock will generally each develop at similar rates. There is also good reason to believe that genetically related animals of differing genetic constitution, living under similar conditions, will maintain their own independent rates of development (9, 125, 126). We need not go to lower mammals to prove this statement, but need only refer to the differences in the rates of development of various parts of the body in Negroes and whites living in the United States (22, 56). It is possible that the maturation rates of the various glands and organs subserving the functions of reproduction likewise differ in groups of differing genetic endowment. This is a suggestion; it is not intended to be more. As far as the human species is concerned there are a vast number of complicating variables which must be taken into consideration in any discussion of so-called racial fecundity potentials; such factors have recently been cogently discussed by Pearl (94).

In groups of mice such as those reported upon by Mirskaia and Crew all extraneous factors were constant; the only variables not constant being presumably the intrinsic ones of difference in genetic constitution. The available evidence very strongly suggests a connection here between the probable genetic difference and the difference in the development of reproductive capacity (24). It is, however, quite possible that other variables may be involved, but upon the nature of these it is unnecessary to descant here; what appears to be likely is that the development of reproductive capacity is genetically determined, but capable of modification by environmental factors, such, for example, as light and temperature (15, 78).

The capacity for efficient reproduction in Mirskaia and Crew's mice was reached by the third month of life, and between this period and the age of six months pregnancies followed matings in these animals in from 80 to 90 per cent of cases. The age at first oestrous of these mice was, coloured 53 days and albinos 34 days. Hence, we may infer an adolescent sterility interval in these mice of some 30 days or so. But as the authors make clear in this study, at least 24 per cent of the animals were fertile upon first mating at oestrous. This is an observation of some importance. Differences in the rates of development leading to puberty and maturity in different individuals, so resulting that some are practically mature at puberty and others not until long afterwards, are the sort of differences which indicate the kind of variation that there is very good presumptive evidence to believe is characteristic of all animals unexceptionally. It is a matter to which we shall have occasion to refer more than once in the following discussions. From Mirskaia and Crew's observations then we may draw the following conclusions:

During puberty their mice were capable of mating, but that of such matings only 24 per cent of conceptions resulted, more than three-fourths of the matings remaining sterile, and thus strongly suggesting the existence of a normal adolescent sterility interval in more than three-fourths of the animals.

With reference to the mice of Mirskaia and Crew we may then define adolescent sterility as *the interval of time from first oestrous during which, in a given population of mice, a majority of normally developing mice are incapable of conceiving and remain functionally sterile.*

This definition renders it clear that not all mice are functionally sterile at first oestrous, but that a majority are. It is

probable that the terms of this definition hold good for all mammals.

As Mirskaia and Crew have shown, not only are 76 per cent of mice sterile at first oestrous, but of the 24 per cent that do conceive 7, or 29.1 per cent, died at or immediately following parturition, while in addition four of the albinos ate their young on the day of birth; such animals as the latter usually dying shortly after devouring their offspring. These figures yield a death rate for first oestrous mothers of 45.8 per cent, a figure extremely and significantly high.

These two facts taken together, namely, the rarity of pregnancy at first oestrous and the high maternal mortality rate among those animals who do conceive at first oestrous, suggest a natural or developmental unreadiness of the female organism for the processes of reproduction at as well as shortly after first oestrous. In this respect, as we shall later have occasion to observe, the evidence for the human species likewise points in a similar direction. As Mirskaia and Crew write, "not only is pregnancy rare at the time of puberty, but it is also dangerous."

In explanation of the uncommonness of pregnancy following mating at first oestrous Mirskaia and Crew have suggested that it is reasonable to assume that "it is because the individual body as a whole is not yet physically fitted for the task though the sex equipment is." In a subsequent passage they write "It is manifest that puberty does not imply maturity of the individual, for when puberty is attained, neither the sex equipment nor the individual are full grown." That is to say, in the mouse the sex equipment though not full grown at puberty is fitted to carry out the processes of reproduction, though the body as a whole is not fitted to support the viable termination of such processes. Mirskaia and Crew have been

able to confirm these conclusions experimentally by provoking precocious maturity of the sexual system of the immature mouse by the injection of pregnancy urine, without producing any associated maturation of the whole body. Coitus in the case of such animals was not followed by pregnancy until the stage at which the first litter is normally produced (81).

As further evidence corroborating the fact of the reproductive unpreparedness of pubertal mice may be cited the same authors' findings that in primiparae suckling their young the pregnancy rate was only 24.1 per cent as compared with 50.0 per cent for nursing multiparae. The difference, according to these investigators, was not due to differences in incidence of ovulation associated with post-partum oestrous, but, they suggest, to a difference between pubertal and adult groups in the level of somatic activity necessary for full reproductive functioning (82).

The differences in the rates of growth of various organs and organ-systems of the body, and in their growth in relation to one another, is a subject which has only within comparatively recent years begun to receive some attention, so that our knowledge concerning these matters is still in a fairly primitive state; nevertheless it has long been obvious that the growth of the animal body presents a rather complex pattern of relative growth. Each organ and the system of which it is an integral part presents its own peculiar growth pattern, and each of these organs and systems in turn present growth functions in relation to one another of varying though definite kinds (20, 123, 61). It is unnecessary here to anticipate our later discussions of this subject, but it may be of service for the clearer understanding of what is to follow to note here that in all animals which have thus far been studied,

and especially in man, a process of rapid growth of the gonads is initiated during puberty, and that in a relatively short space of time during the period of adolescence they reach almost their adult size (62). In the female the musculature (16) and the form and size of the uterus undergo a rapid series of differentiations, approximating almost to the adult condition (46, 109). Such post-pubertal changes in the development of the sexual equipment are chiefly structural. Physiologically the differentiation of the sexual system, most importantly the activities of the glands associated with it, the pituitary and the ovary, proceeds at a much slower pace (27, 93), and it is not until the functions of the latter are properly established that effective reproduction becomes possible. It appears that at puberty the pituitary elaborates a hormone which at first serves chiefly to stimulate the growth of the "sexual equipment," and but slowly serves to initiate those changes in the ovaries which only after some time has elapsed become fully established. It is primarily in the sense of these qualifications that Mirskaia and Crew's statement that "at puberty the individual body as a whole is not yet physically fitted for the task [of reproduction] though the sex equipment is," is to be understood.

Additional support for these observations may be found in the experimental work of Engle (32) on the development of puberty and sexual maturity in mice.

Seventy-two immature mice ranging in age from between 17 and 20 days were the subjects of this experiment. Of these animals 63 were given implants of anterior pituitary lobe daily on three successive days, while in the remaining 11 animals the glands were implanted on the first, second, and fourth day of treatment. In every case the rupture of the vaginal plate occurred at the end of the third day or

during the fourth day. After the third day of treatment the mice were kept with vigorous mature males. This induced precocious rupturing of the vaginal plate, which in normal mice ruptures at about the thirty-fifth day, and was followed by induced first oestrous from one to five days later. Thirty-seven animals mated during this first oestrous. From one to five days after mating 30 of these animals were autopsied. The results were exceedingly interesting.

"Eleven, or slightly more than one-third, were found to have ovulated. In some cases where 2 or 3 days had elapsed before autopsy no eggs were to be found, the tube being full of detritus as in unmated animals killed after ovulation. In these cases the corpora [lutea] were carefully examined, and corpora with retained ova were not found in numbers greater than occurs in normal animals. In other cases 15 to 20 morulae or blastocysts were counted in one tube or uterine horn and checked against the number of corpora lutea. In all cases there was considerable discrepancy, showing that many eggs either had not been fertilized or had degenerated following fertilization. Many of these developing eggs had been fertilized but at the time of examination were beginning to fragment. On the other hand there were found in animals killed at the appropriate stages, many morulae in the tubes, and blastocyst stages within the uterine lumen, which were, so far as could be decided, quite normal, yet none were implanted.

"Of the 5 animals which had been mated more than once, 3 did not ovulate. Seven animals mated on the 1st to 5th day after establishment of the vaginal orifice, but were not sacrificed. If any eggs were fertilized following mating, no animal gave a positive pregnancy sign on the 12th, 13th or 14th days, as is constant in pregnant mice" (p. 409).

These observations fairly conclusively prove that while ovulation may be prematurely induced in the immature mouse by anterior pituitary implants, and fertilization of such ova produced followed by development to morula or blastocyst stage, *implantation does not occur*, presumably owing to the absence of the sufficient anterior pituitary hormone which

must first act upon the corpus luteum. Even in the animal in which oestrous has been precociously induced, the essential remainder of the body is quite unprepared for the function of reproduction.

In the light of these observations Engle makes the point that since these animals cannot be considered sexually mature the term "precocious sexual maturity" cannot justly be used to describe the condition induced in them.

Engle's study of the growth of the ovarian follicle in pre-pubertal mice, in which two distinct phases of growth are noted, from birth to the twelfth day, and from the twelfth day to puberty at the thirty-seventh day, is of interest here as exhibiting the gradual development of the morphological bases for reproduction. On the twelfth day the antrum folliculi is first seen. On the thirteenth and fourteenth days this is slightly augmented, while on the fifteenth day there is a considerable increase in the size of the antral cavity, almost to the average size of the follicle at first oestrous. "From the 15th day to the first oestrous the growth of the follicle has quantitatively no important growth change. What changes do occur are those of tissue differentiation" (33).

It was shown in 1930 by MacDowell *et al.* (70) that the 15th day is a crucial period in the life of the mouse.

Engle draws the following conclusions:

"These studies on the ovarian follicle in the 20 days immediately preceding oestrus, indicate that these large follicles must be secreting—and liberating—certain amounts of oestrin from the 15th day of life, and again emphasize the fact that puberty is a process of slow development, in which the first oestrus or first menstruation is merely an incident, expressive of a cumulative action of a delicate hormone balance in the organism. Since the follicles have attained nearly their full size in less than half the life span before puberty, it is clear that the changes occurring, which cannot be morphologically detected, must be those of slow physiological maturation of the organs

which operating satisfactorily together, constitute the living animal" (33).

And again:

"It is evident that while the interaction of the gonads and the anterior lobe affords the physiological mechanism for the first cycle as for the rhythmically succeeding ones, it is evident that this in turn is influenced by somatic factors, and that a general somatic maturity, as well as genital maturity, is essential to a complete reproductive potential" (p. 418).

In this respect Engle's work constitutes an independent confirmation of Mirskaia and Crew's work on genital maturity and somatic immaturity (81). It is worth noting that Engle considers the rupture of the vaginal plate, the first oestrous, the first ovulation, and the first mating in the mouse as constituting the several phases of the period of puberty (p. 406).

The first phase of puberty in the mouse occurs overtly as rupture of the vaginal plate, followed by oestrous some 48 hours later,—an event which in not more than a third of animals is synchronous with ovulation,—and by mating shortly thereafter. It would seem, however, that since first ovulation occurs synchronously with the first oestrous in slightly more than a third of cases, that it would be better to define puberty according to the various manifestations as they appear in the majority of mice, and perhaps to put ovulation after the first mating. The lag between oestrous and first copulation is generally only a few days, and in the majority of animals ovulation will normally follow during the next cycles after this. Since it is during these latter cycles that pregnancies occur in a significantly large proportion of cases as compared with matings at first oestrous, it would appear reasonable to regard the first ovulation occurring synchronously with first oestrous as a precocious development viably unsatisfactory, and to view those cases in which first ovulation occurs at an appre-

ciable interval after first oestrous as the more normal condition. In both cases, in any event, it would seem that first ovulation is properly to be regarded as a phase of puberty and not of maturity; maturity being perhaps more correctly regarded as that stage at which the reproductive system is at a level of development which enables it to perform the functions of reproduction in a viable and efficient manner.

Quite recently Mills and Ogle (78) in the course of a discussion of adolescent sterility in man in which they cite evidence which they consider to support the existence of an adolescent sterility period in the human species, stated that such evidence would not be considered conclusive "without corroboration on experimental animals under controlled conditions. We have no records of timing of intercourse in . . . human cases . . . hence much of the discussion must remain problematical. It so happens, however, that animals give definite evidence of this same adolescent period of sterility . . ." The experimental animals referred to being white mice.

The suggestion that the findings on mice may be used to "corroborate" the existence of an adolescent sterility period in man and render the evidence for such a period in man conclusive, is open to some question. Mice and men are two very different systems of variables, and sequences of facts observed in connexion with the one cannot be generalized to hold good for the other. The most that can be said here is that since mice and men are mammals, and since in a general way their bodies grow and function in a similar manner it is possible that, allowing for all the differences in rates of growth and development *et cetera*, a similar infecundity period characterizes the early adolescent human individual. As Hartman (51) puts

it, "what is phylogenetically significant is apt to be physiologically fundamental."

Such a possibility would be tantamount to a guess were it not for the fact that in all the animals so far investigated the facts all point in the same direction. It is, however, one thing to speak in terms of possibility, and quite another to speak of "corroboration" and the rendering "conclusive" of evidence projected from one distinctive group to the uncertain evidence of another very different one.

The evidence which Mills and Ogle's study corroborates and renders conclusive is that of Mirskaia and Crew (80, 81), although they do not refer to the work of the latter investigators.

mothers were allowed to deliver their young in the control room and kept there with the litter until the young were 21 days old. This was necessitated by the fact that the mothers usually kill the young if left in either the heat or cold.

"From Table 1 we see the first oestrus, corresponding to the human menarche, beginning at 33 days of age in the control room group, at 36 days for the young of control room mothers placed in the cold room at 20 days of age, at 33 days for the cold room young of cold room mothers, and at 35 days for the young of control room mothers shifted daily from hot to cold. Young placed in the moist heat, however, show a definite and striking delay in the age of first oestrus. Young of control room mothers, placed in the heat at 20 days of age, began the oestrus at 37 days of age, but the young of the hot room mothers were delayed to 46 days, confirming our earlier statements on the later menarchial age for girls of native tropical stock," (pp. 612-613).

TABLE 1*
First oestrous and first delivery data on white mice

| DESCRIPTION OF GROUP | NO. OF CASES | AVERAGE FIRST OESTRUS (days) | AGE AT FIRST DELIVERY (days) | LAG IN FERTILITY FIRST OESTRUS TO FIRST CONCEPTION (days) |
|------------------------------|--------------|------------------------------|------------------------------|---|
| Breeding room controls..... | 20 | 33 | 84 | 31 |
| Cold room immigrants..... | 11 | 36 | 88 | 32 |
| Cold room descendants..... | 25 | 33 | 79 | 26 |
| Hot room immigrants..... | 31 | 37 | 94 | 37 |
| Hot room descendants..... | 9 | 46 | .. | .. |
| Change group immigrants..... | 26 | 35 | 138 | 83 |

* After Table 4 Mills and Ogle.

Mills and Ogle were interested in the relation between climate and the onset of menarche, and in the effect of climate upon the fertility of man; in order to learn something of the nature of this relation they resorted to white mice as their experimental animals. The account of their experiment and their results is best set out in their own words:

"Mice, grown from a single stock, were divided into four groups. One group was kept in the control breeding room at 70-80°F., another was placed in a special room kept at 64-68°F., and a third placed in a hot room kept at 88-92°F. and about 70 per cent relative humidity. A fourth group was shifted daily between the hot and cold rooms, spending 12-16 hours of each day in the moist heat. In every case pregnant

From these observations the following facts emerge:

(1) Only 5 per cent of each of the groups of mice conceived at each of the first three oestrous periods, and it was not until the 6th and 7th oestrous periods that full fecundity was established. (2) The earlier the appearance of the first oestrous, the longer was the lag in fertility. (3) The later the appearance of oestrous, the shorter was the absolute lag in fertility. (4) The average lag in fertility for three normal control groups of mice was 31.8 days. (5) Stimulating cold produced a quickening in sexual development. (6) Moist heat produced a depression and a

slower development of the sexual functions, and an increase in the fertility lag. (7) Great temperature variability produced a marked suppression of fertility.

We may conclude, then, from the work both of Mirskaia and Crew and of Mills and Ogle on different stocks of mice under very different conditions, that the majority of mice are characterized by an adolescent sterility period of some 31.8 ± 1.9 days.

THE RHESUS MONKEY

The next group of animals which has been the subject of investigations which can be safely utilized in discussing the question of adolescent sterility is represented by the rhesus monkey (*Macacus sive Pithecus rhesus*). These investigations were carried out by C. G. Hartman on the Carnegie colony of animals at Baltimore and first briefly reported in 1931 (52). In this communication Hartman adduced evidence to show that the generally accepted belief that puberty and maturity or reproductive capacity are synonymous or synchronous phases of development is erroneous. From his examination of the evidence Hartman was led to the conclusion that the interval of time which normally elapses between puberty and maturity in man, monkey, and rat "is about what one would expect with the application of Donaldson's law of equivalent ages: three years, one year and one month, respectively, for man, monkey and rat" (p. 226).

Reporting his findings on fifteen rhesus monkeys whose every menstrual cycle had from its inception been carefully observed, Hartman writes:

"these fifteen females averaged 3,350 grams in weight at the first menses. Most of them were mated soon after puberty, but not a single female conceived before attaining a weight of 4,370 grams. The average weight at first conception of nine of these

females was 5,000 grams hence it; is apparent that many menstrual cycles passed between the first menses and the first conception, despite frequent matings in the interval. The interval may be estimated at about a year of time" (p. 226).

In these young animals Hartman found that "the menstrual cycles of the young females are extremely irregular in length and duration, and there is a very slow incidence of ovulatory as compared with non-ovulatory cycles" (p. 226).

In his monograph on the reproduction of the rhesus monkey published in 1932 Hartman (53) makes it quite clear that the failure to ovulate is "the probable cause of the relative sterility of adolescent females" (p. 23).

In his earlier communication (52) Hartman went on to suggest that similar conditions characterize the human female, and that although the mores of a given people may force effective marriage upon the girl at her first menstruation, "there is much indication that, by and large, nature herself prevents motherhood supervening during an important series of preparatory years" (p. 226). The greater part of the communication is, in fact, devoted to the establishment of a case for the existence of a period of relative sterility in the adolescent human female, the concluding statement of which is to the effect that "It seems highly reasonable that Malinowsky's (*sic*) predicament is explained by the facts presented in this paper, namely, that the first menstruation (*puberty*) marks merely an early manifestation of a train of events (*adolescence*) which only after three or four years on the average lead to ovulation and conception, the proof of *maturity*" (p. 227).

From Hartman's observations on the rhesus monkey it is very clear that in this animal the development of sexual maturity is a very gradual process; a function of growth, prior to the completion of which

the animal remains functionally sterile, about one year of time elapsing from the appearance of the first menstruation before the animal is able to conceive. Hartman (53) writes:

"it appears that the average age of the rhesus female at first conception is pretty nearly 5,000 grams, which, although the number is still small, [a total of 9 available records of conception and 15 of menstruation], nevertheless definitely points to a considerable period of adolescent sterility, inasmuch as practically the same opportunity for insemination was afforded before the first conception as after.

"A similar relative sterility, I am convinced, also occurs in very young girls" (p. 24).

Hartman points out that the terms adolescence, puberty, and maturity are often used loosely and interchangeably, and for the purposes of his own study defines these terms as follows:

"*Puberty* is used synonymously with the menarche, that is, the time of the first menstruation; *maturity*, the age of the first ovulation and the first uterine preparation for pregnancy; *adolescence*, the two periods combined, that is, the entire period when reproductive functions are in the process of attaining the climax, reproductive capacity, namely, ovulation, fertilization, implantation. For there is reason to believe that adolescence is not a sudden but a gradual change in the life of the individual mammal and that in primates the first ovulation is separated by months and perhaps years from the first menstruation.

"Some observations on the monkeys of the Carnegie Colony have led to these conclusions. In the first place no adolescent female has conceived during the first two years after puberty. Furthermore, there is a very high incidence of non-ovulatory cycles in young animals. These observations point to the failure to ovulate as the probable cause of the relative sterility of adolescent females" (45, p. 23).

It will be recalled that in his earlier communication Hartman (52) gave the interval between menstruation and first conception in his rhesus monkeys as "about a year of time" (p. 226). In his 1932 monograph (53) he states that "no adolescent female has conceived during the first two years after puberty" (p. 23).

A careful study of Hartman's protocols indicates that the first estimate of about one year is the correct one, and in a personal communication Dr. Hartman has been kind enough to confirm this.

In summarizing the evidence Hartman (53) concludes:

"adolescence is a period of endocrine instability, as evidenced by irregular menstruation, preponderance of menstruation without ovulation, follicular atresia, excessive swelling of the sex skin, comparative sterility. The sterility of adolescence is due to failure to ovulate. This, of course, entails a failure of the uterus to undergo the pregravid changes in preparation for the reception of an egg. It is highly probable that the uterus 'learns' to undergo these changes in a step-like fashion, the organ growing a little larger with each succeeding cycle in which the ovary likewise produces a larger and larger follicle until this no longer degenerates but goes 'over the top' and ovulation occurs" (p. 26).

THE CHIMPANZEE

The only other animal for which a certain amount of reliable information is available with reference to the problem of adolescent sterility is fortunately a close relative of man, namely, the chimpanzee.

Tinklepaugh (125) reported in 1933 a chimpanzee, Dwina, in whom the first menstrual bleeding was observed when she was at an estimated age of 9 years. The first swelling of the sex skin had appeared 5 months previously and there were four cycles of sex swelling before the establishment of menarche. Dwina was continuously caged with a mature male but conception did not take place until four months after the first menstruation. The sterility interval in this animal then was only four months. It is of interest here to note that this mother died 15 days after giving birth. She may have died of puerperal septicemia, or from the inability to withstand the strain upon her system. Recalling the fate of early conceiving mice it would look as if Dwina had possibly

conceived too early in her development for her own good, and in this respect her history would correspond to the early-conceiving mice of Mirskaia and Crew, almost half of whom either died or ate their young. This is rendered all the more probable when we consider the following two well-authenticated cases.

Yerkes (137) reported in 1935 on a second-generation captive-born chimpanzee, Cuba, as follows: "She first exhibited characteristic genital swelling [oedema of the sex skin] in April 1933. Menstrual bleeding occurred first on July 10, 1933, when she was seven years, four months, old. She was caged with a mature male from May, 1933, and she became pregnant August 9 (\pm 5 days), 1934, at the age of eight years, five months" (pp. 542-543).

The sterility interval in this chimpanzee was then one year and one month. It is further to be noted that in this case parturition, which occurred on April 11th, 1935, was uneventful and that the mother and infant both did well, the infant weighing close to four pounds at birth.

"Mother and infant were observed continuously from 3:20 to 4:10 P.M., and both verbal and pictorial records were made of their behavior. As primiparous mother Cuba exhibited behavioral inadequacies. Although from the first she carried Peter about with her, holding him awkwardly, usually grasped in one hand, she did not, according to species practice, place him upon her abdomen or breast and permit him to cling to her. Instead she treated him much as she might any strange object which interested, puzzled and annoyed her. Toward the end of the period of observation she forcibly broke his hold upon her whenever he succeeded in grasping her hair or skin with hand or foot. Often in so doing she was rough and impatient and vocalized complainingly.

"Peter was left with his mother for about eighteen hours (overnight) under intermittent observation. As Cuba did not accept him, to be nursed and generally cared for, it was necessary to take him from her, in order that he might not become the victim of her inexperience, curiosity, neglect or abuse" (pp. 542-543).

One may well raise the question whether it is possible that these behavioral inadequacies are in some significant way, apart from the factor of experience, associated with the degree of reproductive maturation of the animal? Or is the factor of experience perhaps the important thing here? (132, 139).

In connexion with Cuba Dr. J. H. Elder informs me that this animal has exhibited somewhat similar behavior with her second infant; although she kept it by herself she did not, however, care for it in a satisfactory manner, so that after some seven weeks it had to be taken from her because of serious undernourishment.

In the Johns Hopkins chimpanzee, Evo, reported in 1935 by Schultz and Snyder (111)

"the sex skin became oedematous for the first time when she possessed all her permanent teeth except the third molars, and at the carefully estimated age of 9 years and 1 month. . . . This swelling persisted for nearly 8 months, *i.e.*, until a few days before her first menstruation" (p. 194).

"The first menstruation of Evo occurred at the estimated age of 9 years and 9 months, and 9 months before the eruption of the lower third molars" (p. 195).

Evo was continuously together with a mature male, Dayton, from an early age, although intercourse did not take place until after her 7th menstrual cycle, or approximately 8 months after her first menstruation, when after

"coitus between the two was continued fairly regularly 3 and more times daily for approximately 6 months or for several weeks after she became pregnant" (p. 197).

"... in spite of regular menstruation on the part of the female and abundant coitus on the part of both sexes, no conception took place for a considerable time, namely, for at least 5 months after the first possible exposure and until after the 11th menstrual period, which occurred exactly 1 year after the first menstruation. Evo's estimated age at the time of conception was 10 years and 9 months, or 3

months after her lower third molars had appeared, and about 8 months before her permanent dentition became completed by the eruption of the upper third molars" (pp. 197-198).

It appears then that in Evo the sterility interval lasted for one year. On the 188th day (after the onset of the last menstruation) Evo's health changed for the worse, and on the 196th day of pregnancy she spontaneously aborted a still-born fetus. She subsequently made a good recovery.

Here, once more, is the case of a first pregnancy in an adolescent chimpanzee which terminated unsuccessfully, and again we see here the suggestion that pregnancy in the immature animal is a dangerous process, which will frequently tend to end fatally either for the mother or offspring or both. We may recall here McLaren's report of the only two native girls who in all his eight years at Cape York were alone in giving birth to children before they were married, their offspring being still-born and undeveloped (76).

Concerning the two other chimpanzees in the Johns Hopkins colony the authors write:

"In the second female Hopkins chimpanzee, Mac, the first sex swelling appeared at a dental age closely corresponding to that in Evo, [*i.e.*, about 9 years and 1 month], but, in contrast to that in Evo, this swelling lasted for only about 3 weeks, and has not reappeared at the time of writing, about 5 weeks later. In the third female Hopkins chimpanzee, Pandora, the sex swelling had made its first appearance before the permanent canines had erupted and persisted very pronouncedly for approximately 14 months. Neither Mac nor Pandora has as yet menstruated" (p. 194).

The authors do not tell us whether Mac was ever exposed to Dayton, the mature male, but they state that at "About the time of Evo's first menstruation the younger Hopkins female, Pandora, was

added to the colony. Dayton had regular and frequent sexual intercourse with Pandora from the start, even though she never menstruated but showed merely pronounced sex swelling throughout the period from her arrival to the present" (p. 197).

Dr. J. H. Elder has recently (14.2. '38) very kindly supplied the writer with data concerning the reproductive history of the chimpanzee, Soda, which has been under observation for some years at the Yale Laboratories of Primate Biology, Florida. Beginning about the first of June, 1935, at an estimated age of 7 years 11 months Soda showed very slight enlargement of the external genitalia, which persisted with almost imperceptible variations until August 19, when it disappeared entirely. The swelling began again on September 22, and this time resembled more closely the typical swelling, although at this time it was still much smaller than those exhibited later. First menstruation occurred November 18, 1935 at an estimated age of 8 years 4½ months. Conception occurred on the 19th day of the seventh cycle, on or about September 11, 1936. Since, however, there were only four opportunities for conception in the cycles previous to the seventh, it is not possible to say with certainty that this animal did not ovulate, or was incapable of conception, before the seventh cycle. But since on these four previous occasions she was mated with a mature male at the optimum mid-interval period for conception, there is a good probability that she had not previously ovulated, or at least, that she was not previously capable of conception. The menarche-conception interval in this case may then tentatively be said to have been 10 months.

From histories such as those given above it seems probable that the chimpanzee is

normally incapable of conceiving until some appreciable time after the establishment of menarche.

Two additional records of uncertain value may be noted here.

Fox (38) in an extremely interesting paper, written in 1929 on births observed in two anthropoid apes, reported on a chimpanzee, Marianne, who had come to the Philadelphia Zoo in 1924 when she was estimated to be about 3 years old. She first began to menstruate in 1926 at the age of five years, but it was not until she was seven and a half years old that conception took place. During the intervals between menarche and conception she was caged with a male chimpanzee of her own age. Schultz and Snyder state that "a male was not continuously present during this time" (99, p. 198), but this is not so according to Fox. Inter-course, according to him, took place frequently between the animals during this period. In a personal communication (15. 3. '38) Dr. Fox writes

"The companionship in the same cage of the male and female chimpanzee was uninterrupted from menarche to conception. That is what can be read from my article of 1929. . . . They came together and grew up together. There is no reason to think that any period of time passed when they were separated so that from the institution of menstruation of the female chimpanzee until conception the two must have experienced the same physiological development of sexual maturation together and each under the influence of the other.

Since the somewhat younger male may have been in process of maturing during a part of the time when the female had already attained to reproductive capacity, it is difficult to draw any definite conclusion from this case.

Similarly for the chimpanzee Boo-Boo of the London Zoological Gardens, reported by Wyatt and Ververs (136), the evidence is not quite clear. Boo-Boo

first menstruated at an estimated age of 8 years in 1931. She was not, however, put together with a mature male until three years later in June 1934, whereupon she promptly conceived, being at an estimated age of 11 years at the time of conception.

These various observations on the chimpanzee yield four cases in which the conditions necessary to enable one to make a fairly satisfactory judgment concerning the existence or not of a period of adolescent sterility in the chimpanzee have been more or less adequately fulfilled. These cases tabulated according to each investigator's presentation of the data are summarized in Table 2.

Upon the basis of the evidence provided by these four cases it is possible to say that the degree of probability that the chimpanzee is normally characterized by a period of adolescent sterility is fairly high, for it is unlikely that it is purely due to accidental factors that in the only four cases for which we have reliable evidence the facts should all point the same way; and further, such evidence as is provided by the cases of Marianne and Boo-Boo, though not altogether satisfactory, negatively supports the existence of such a period of sterility in these particular animals, indicating in the latter case that when a sufficient length of time has elapsed following the appearance of menarche the animal is capable of conceiving promptly when put together with a mature male. In the case of Boo-Boo the conditions parallel those existing among human groups, where marriage and effective intercourse do not occur until a considerable interval after the establishment of menarche, when the promptitude with which conception follows intercourse obscures the possible existence of an adolescent sterility period in the human female.

It is necessary to be quite clear here con-

cerning the fact that with the exception of Yerkes' data all ages given for the animals referred to above are *estimated*. Schultz, who is our best authority on the estimation of the age of primates, may be relied upon to have given as nearly accurate an age for Evo as possible. Even so it is not unlikely that the age of this animal was somewhat less or more at menarche than the age estimated by Schultz. Dental age, as Schultz has himself shown (110), is not a reliable index of chronologic or even physiologic age. In the case of Dwina Schultz is of the opinion that she was less than 8 years of age at menarche

versity, Zuckerman and Fulton (144) observed the first sexual skin swelling when the animal was at an estimated age of 7 years; irregular fluctuations in the amount of swelling being noted during the subsequent years.

Arranging the data for first sexual skin swelling and menarche, as in Table 3, certain interesting facts are seen to emerge.

Since the ages given in Table 3 are with one exception all rather hazardous estimates, and the number of cases so small, it would be unwise to attempt any elaborate analysis of the findings there presented. Actually, we can at present say very little

TABLE 2

Developmental sexual history with especial reference to the adolescent sterility interval in the chimpanzee

| OBSERVER | ANIMAL | FIRST SEXUAL SKIN (date, age) | SEXUAL SKIN SWELLINGS IN- CEPTION TO MENARCHE | MENARCHE (date, age) | FIRST CONCEPTION (date, age) | DELIVERY (date, age) | ADOLESCENT STERILITY INTERVAL |
|----------------------------|--------|----------------------------------|--|---------------------------------|----------------------------------|-------------------------------|-------------------------------|
| Tinklepaugh 1933 | Dwina | May, 1929 8 yrs. 8 mos. | 4 | Sept. 8, 1929 9 yrs. | Jan. 8, 1930 9 yrs. 4 mos. | Sept. 11, 1930 10 yrs. | 4 mos. |
| Yerkes 1935 | Cuba | Apr., 1933 7 yrs. 1 mo. | 3? | July 10, 1933 7 yrs. 4 mos. | Aug. 9, 1934 8 yrs. 5 mos. | Apr. 11, 1935 9 yrs. 1 mo. | 1 yr. 1 mo. |
| Schultz and Snyder 1935 | Evo | 9 yrs. 1 mo. | Continuous until two weeks before menarche | 9 yrs. 9 mos. | 10 yrs. 9 mos. | — | 1 yr. 0 mos. |
| Elder 1938 | Soda | June 1, 1935 7 yrs. 11 mos. | 2 | Nov. 18, 1935 8 yrs. 4½ mos. | Sept. 11, 1936 9 yrs. 1½ mos. | May 5, 1937 10 yrs. 0 mos. | 10 mos. |

(p. 502), rather than 9 years as estimated by Tinklepaugh.

Marianne was probably 2 years older than the 5 years assigned to her by Fox at menarche; while Boo-Boo's estimated age of 8 years at menarche probably represents a near approximation to her true age.

Two other chimpanzees for which information is available concerning inception of sexual skin swelling and menstruation may be added to our number here. In the animal "S" at the London Zoological Gardens Zuckerman (141) noted sexual skin swelling for 2 years before menarche. In the animal Kani of the Department of Physiology at Yale Uni-

versity, Zuckerman and Fulton (144) observed the first sexual skin swelling when the animal was at an estimated age of 7 years; irregular fluctuations in the amount of swelling being noted during the subsequent years.

Arranging the data for first sexual skin swelling and menarche, as in Table 3, certain interesting facts are seen to emerge.

Since the ages given in Table 3 are with one exception all rather hazardous estimates, and the number of cases so small, it would be unwise to attempt any elaborate analysis of the findings there presented. Actually, we can at present say very little

concerning the average age at which the reproductive functions make their appearance in the chimpanzee, but if we were forced to hazard a suggestion on the basis of such evidence as that cited above we should have to put the average age of the appearance of the first sexual skin at 8 ± 1 years, and age at menarche at 8 years 6 months ± 15 months. The sexual skin-menarche interval would thus be of 6 ± 3 months duration. It is of interest here to note that in a paper published in 1937 by Spence and Yerkes (120) on the Florida colony of chimpanzees the authors found that "the average age of seven animals (six of estimated age) at the time

of the first menstruation was 8.0 years, the range being 7.25 to 8.33 years." (p. 242). As will be observed these figures are remarkably close to those which have been given above.

What is brought out fairly clearly in Table 3 is that there is a considerable amount of variation, in and as between different animals, in respect of the age of appearance of first sexual skin swelling, and in the duration of the interval between the first sexual skin swelling and men-

In man such a pre-menarchial phase undoubtedly also occurs, but of this external evidences akin to those seen in the sexual skin of the chimpanzee have neither been sought for nor demonstrated. Although the fact is easily confirmed John Hunter (1748-1793) appears to have been the first (*ca.* 1787?) to have drawn attention to the changes in the pudendal skin color with pre-pubertal growth and during pregnancy in the human female. He writes: "The skin of the pudenda grows redder and

TABLE 3
The sexual skin in relation to menarche in the chimpanzee

| OBSERVER | ANIMAL | AGE AT FIRST SEX SKIN | NUMBER OF SEX SKIN CYCLES PRIOR TO MENARCHE | AGE AT MENARCHE | INTERVAL BETWEEN FIRST SEX SKIN AND MENARCHE |
|---------------------------|----------|-----------------------|---|--|--|
| Fox 1929 | Marianne | ? | ? | 5 yrs. | ? |
| Zuckerman 1930 | "S" | ? | ? | ? | 2 yrs. |
| Tinklepaugh 1933 | Dwina | 8 yrs. 8 mos. | 4 | 9 yrs. | 4 mos. |
| Zuckerman and Fulton 1934 | Kani | 7 yrs. | 8? | Never menstruated | — |
| Wyatt and Vevvers 1935 | Boo-Boo | ? | ? | 8 yrs. | ? |
| Yerkes 1935 | Cuba | 7 yrs. 1 mo. | 3 | 7 yrs. 4 mos. | 3 mos. |
| Schultz and Snyder 1935 | Evo | 9 yrs. 1 mo. | Continuous swelling for 8 months | 9 yrs. 9 mos. | 8 mos. |
| Schultz and Snyder 1935 | Mac | 9 yrs. 1 mo. | 1 +? | 5 weeks later sex swelling just re-appeared; no menstruation | ? |
| Schultz and Snyder 1935 | Pandora | 8 yrs. 6 mos. | Continuous swelling for 14 months | No menstruation | 14 mos. +? |
| Elder 1938 | Soda | 7 yrs. 11 mos. | 2 | 8 yrs. 4½ mos. | 5½ mos. |

arche. The same holds true, as Schultz and Snyder (111) have shown, for the menstrual cycle. Such variability is, of course, to be expected, and the differences observed are probably to be ascribed to individual differences in rate or degree of development of the reproductive system; but this is a problem for future research to determine.

The first sexual skin swelling of the chimpanzee is the outward sign of beginning reproductive maturation, the overt sign of the first phase of this process.

redder to the years of puberty, and seems to have little or no rete mucosum. When a woman is with child these parts grow darker, even darker than the other skin, like the nipple; which colour does not terminate at once, but is gradually lost. This darkness extends to the 'nymphae' and 'carunculae myrtiformes'" (60).

Such changes, of course, reflect the activity of certain internal secretions, and it is probable that the sex hormones which are poured into the blood stream during the normal oestrous cycle of the human

female produce changes in the skin of the pudendal region which are related to the sexual skin phenomena of sub-human primates, although in man the well-known menstrual skin changes tend to be rather more diffuse (14) than localized (124). It is, however, quite possible that such changes are in the human female limited to the pubertal, pregnancy, and lactation periods. In this connexion it may be noted here that while in most of the Catarrhine primates in which the sexual skin has been reported the condition appears to be a cyclical phenomenon associated at first with beginning ovarian activity and eventually with imminent ovulation, it is, according to Hartman (53) in the rhesus monkey limited to the period of adolescence, and only rarely appears in the adult (p. 24). This observation has in 1938 been confirmed by Zuckerman (148), who has elsewhere (147) also stated that the rhesus monkey rarely experiences *marked* sexual skin swelling (p. 324). In 1938 Schultz (112) showed that sex skin swelling occurs in the Bornean orang, but this appears to be limited to the period of pregnancy. Sex skin phenomena such as occur in the chimpanzee have never been observed in any of the developing or mature gorillas which have been under observation in various zoological gardens. Raven (100), however, stated in 1936 that while trailing a group of mountain gorillas (*Gorilla beringei*) west of the southern end of Lake Kivu in the Belgian Congo, he saw, at a distance of some 40 yards, an apparently adult female: "The genital region of this individual was swollen, pale in color, and appeared to be tumid. I judged that the swelling was similar in size to that of a female chimpanzee during maximum enlargement, and thus proportionately smaller, considering the larger size of the gorilla" (p. 416). Then the animal disappeared from view. It may

be that 40 yards is not a satisfactory distance at which to judge the state of the genital region of a departing gorilla; but anyone who has once seen the sexual skin swelling of a chimpanzee during its maximum enlargement would have very little difficulty in recognizing it at such a distance. Raven is an excellent observer with unrivalled field experience; his observation is therefore not to be lightly considered. The fact, however, remains, that no one has ever made a similar observation. The late Dr. C. V. Noback shortly before his death informed me that the post-pubertal gorilla (*Gorilla gorilla*), Janet Penserosa, at the New York Zoological Park, which he had had under more or less continuous observation since its infancy, although she had menstruated a number of times never exhibited any circum-anal skin changes, but that a "premenstrual" swelling of the labia majora occurs; that is, before each menstruation, according to Noback, there is a turgid swelling of the labia majora which ceases during menstruation and does not recur again until shortly before the next menstruation. This fact was briefly reported by Noback in 1936 (92). At his invitation I was able to confirm the presence of such a swelling on two separate occasions (March, and October, 1936), but I am unable to say exactly when these swellings occurred in relation to the oestrous cycle. Upon examination the labia majora were found to be distinctly tumid and remarkably soft to the touch, yielding easily upon light pressure. Their color was a glistening black, very distinguishable from the dry scaly gray-black color of the rest of the perineal region. It is quite possible that in respect of the sexual skin swelling there is a specific difference between *Gorilla beringei* and *Gorilla gorilla*. The sporadic distribution of the sexual

skin among the primates led Zuckerman (143) to suggest in 1933 that this character has developed independently among the different primates (p. 47).

In 1886 Hartmann (55) referred to "die meist farbrigen Zeichnungen der weiblichen Genitalen eines älteren Gorilla-Weibchens vor, welches, obgleich nur schlecht in Weingeist conserviert," but it is not certain whether this may be taken as evidence of the existence of a sexual skin in this animal, which was presumably of the species *gorilla*.

In the animal (*Gorilla gorilla*) Pussi which was at the Zoological Gardens of Breslau from September 3, 1897, when she was estimated to be 4 years of age, to the date of her death from chronic nephritis on October 6, 1904, though carefully sought for no evidences of menstruation (41) nor of swelling of the labia were ever observed. Zuckerman (143) states in 1933 that certain anatomical observations of Gerhardt in 1906 (40) seem to support the view that the gorilla shows sexual skin changes; but this must be an error for Gerhardt explicitly states that "Periodische Blutungen aus den Genitalen oder Schwellungen der Schamlippen, die sich sonst bei den erwachsenen Affen, und auch beim Schimpansen finden, sind hier nie aufgetreten" (p. 635). Nor did Director Grabowsky (41) ever observe such changes. Section of Pussi's ovaries revealed a total absence of ripe ova or any evidences of corpora lutea; only a few large follicles were present. Yet this animal, Gerhardt believes, was almost certainly not less than 11 or 12 years old (p. 634) at the time of its death.

I have calculated from the published data of Noback (90, 91, 92), that Janet Penserosa was 9 years and 7 months of age at the time (29. 3. '36) of her first observed menstruation, which is an estimate

probably more near the true age of menarche in the gorilla than one would be led to believe from the conditions observed in Gerhardt's specimen.

In condition of genital swelling, and age at menarche, the gorilla would appear to resemble man more closely than the chimpanzee. But let us return to the chimpanzee.

Physiologically and developmentally the sexual skin swelling of the chimpanzee means that a gonadotropic hormone elaborated by the anterior lobe of the pituitary sufficient to produce maturation of the follicles in the ovaries, but generally insufficient to produce ovulation, stimulates the release of the follicular hormone oestrin which, among other things, produces an accumulation of intercellular fluid in the perineum (141, 142, 143, 144, 145, 146, 147, 148), the change thus produced being observable during the period of coitrectation as the swelling of the sexual skin. It is here suggested that the first appearance of the sexual skin in primates is a phenomenon akin to the rupture of the vaginal plate in mice and rats, for the evidence indicates that the two events are fundamentally due to the operation of similar factors in the two groups of animals. In the guinea-pig the period immediately preceding the first oestrous, the proestrus, is marked by congestion and swelling of the external genitalia (63); the same holds true for dogs.

It is important to note here that in the chimpanzee Kani, reported by Zuckerman and Fulton (144), when, after a year of irregular sexual skin swelling without menstruation having yet appeared, the ovaries were removed and serially sectioned, it was found that none of the follicles was larger than 2 mm. in diameter, most being in process of atresia. No luteal tissue was anywhere observed, in-

dicating that follicular growth had never proceeded beyond this stage, and that ovulation had never occurred. Thus, after a year of sexual skin activity, towards the end of which, it may be mentioned, the animal was not in good health, Kani had neither menstruated nor ovulated. It is, of course, very unlikely that ovulation would *normally* ever occur before menstruation; it may be safely assumed that ovulation as a rule normally takes place at some time after the first oestrous or menarche.

Such local changes: rupture of the vaginal plate, oedema of the external genitalia, or sexual skin swelling, are clearly to be regarded as parallel stages falling into the period of puberty in the development of the reproductive functions; for it is fairly clear that at this stage of sexual development neither mouse, rat, guinea pig, nor chimpanzee is ready for normal reproduction.

Such changes represent the phenomena of the progress of reproductive maturation preceding the development of those processes which result in maturity, or the functional capacity to reproduce viably. Puberty, upon this view then, is the period of maturation during which the organism undergoes a series of morphological and physiological changes upon the completion of which the organism is said to be reproductively mature. That is when the period of puberty may be said to terminate and the period of sexual maturity to begin, and as has been shown, during the period of puberty the organism appears to be relatively sterile.

With respect to the duration of the adolescent sterility interval in the four chimpanzees for whom the evidence is reasonably clear, we may note that this lasted for 13 months in Cuba, 12 months in Evo, 10 months in Soda, and 4 months

in Dwina. Again, this is the sort of variability which one would expect. What the average duration of the sterility interval in the chimpanzee is we do not know, but it is probable that it is nearer the 13 months of Cuba than the 4 months of Dwina. No doubt, as in all the mammalian forms thus far surveyed, the chimpanzee is in a certain small proportion of cases capable of conceiving at or shortly after first oestrous; and this is probably true of all mammals including man, but such cases though perfectly normal are in the minority, and more often than not represent individuals who are biologically unprepared to carry out the processes of reproduction efficiently. The so-called adolescent sterility period is merely a measure of the chronologic time during which the organism is developing towards the attainment of a condition of *efficient* sexual status, that is, maturity. It is clear that this status is attained only gradually following the establishment of the first overt signs of puberty. Differences in the rates of development of different individuals will, of course, determine when in relation to puberty this status is reached in chronologic time. A perfect demonstration of this fact was provided in 1937 by Engle *et al.* (35) for first oestrous and growth rate in the rat.

In terms of physiologic time it is not difficult to understand that an animal may mature very rapidly after the appearance of the first oestrous and reach a physiological stage of maturity equal to that of an animal which has matured at an appreciably slower rate and is chronologically appreciably older at maturity. In chronologic time there will be a great difference in the duration of the sterility interval, in physiologic time there may be none. This may be stated both as a fact

and as an hypothesis to account for the observed differences among different animals in the interval elapsing between first oestrous or menarche and the development of efficient reproductive capacities.

The evidence for the mammals thus far surveyed if it does not prove at least very strongly suggests the existence in the majority of adolescent or immature ani-

mals of a condition of sexual immaturity during which the animal is incapable of reproduction. The duration of this condition of relative sterility, counting from the first oestrous, is of variable length in different animals, and is probably correlated with their individual rates of development.

(To be concluded)





BIOLOGICAL EFFECTS OF POPULATION DENSITY IN LOWER ORGANISMS (*Concluded*)

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2. DROSOPHILA

a. Culture

INFORMATION as to the general biology of *Drosophila* will be found summarized in Sturtevant (1921) and Morgan, Bridges, and Sturtevant (1925). *Drosophila* is ordinarily mentioned as a fruitfly since decaying fruit is its natural food, and large numbers of them always collect seemingly out of nowhere whenever a bit of over-ripe fruit is left exposed in warm weather. Northrop (1917a) found that they cannot be raised successfully on sterile banana, although decaying banana is an excellent medium. He was unable to raise them on a sterile mixture of pure protein, sugar, salts and fat but the larvae would grow on the kidney, liver, and pancreas tissue from a dog and on the dead bodies of flies themselves. They did quite well on yeast alone while the addition of banana, casein, or sugar to the yeast increased the percentages which were able to develop showing that these substances could be utilized to some degree by the flies as food. Baumberger (1919) found that by soaking eggs for 10 minutes in 85 percent alcohol he could sterilize them so that when they were placed on sterile food they would not inoculate it with yeast, mold, or bacteria. Keeping the medium sterile in this way, he found that *Drosophila* larvae do not grow well on sterile food but that bac-

teria and molds may take the place of yeast. A loose symbiosis exists between yeast and *Drosophila*, the yeast being spread by the flies which depend upon it to synthesize many non-protein nitrogenous compounds into proteins for themselves. Northrop (1926b) says, however, that by the proper choice of foods he has been able to raise *Drosophila* under aseptic conditions in the dark for 230 generations. *Drosophila* were ordinarily raised in the laboratory on decaying banana and later on banana agar seeded with yeast which was easier to handle. This, however, was a very variable food substance since it depended upon the ripeness and other qualities of the bananas which changed seasonally and could not be well controlled. For his quantitative experimental work, Pearl particularly desired a standard food which could be duplicated in precisely the same fashion at any time. After trying a number of mixtures, Pearl and Penniman (1926) and Pearl, Allen, and Penniman (1926) developed a purely synthetic medium which met the requirements admirably. It is primarily a medium for the growth of yeast which is sprinkled over it in powdered form after it has solidified in the culture bottles. The pH is so regulated as to discourage the growth of bacteria and molds which give trouble particularly at low temperatures. This synthetic medium, called S-101, has been used as the standard fly culture medium

ever since in this laboratory. The ordinary stock is cultured in half-pint milk bottles with about one and a half inches of medium in the bottom which is seeded with yeast before the flies are put in the bottle. Five pairs of flies are placed in each bottle which is closed with a cotton plug to permit circulation of air and is kept at a constant temperature of 23°C. The parents are removed a day or two before the offspring begin to emerge from the pupa cases. Bridges and Darby (1933) have since developed a medium with a base of corn-meal and molasses, substances which are however natural food products of variable composition and can in no scientific sense be regarded as forming a constant medium, for which they claim superior qualities. The S-101 medium has in every way proven satisfactory here.

b. Population growth

As has already been noted, Pearl (1925 and 1927) showed that population growth for *Drosophila* follows the typical logistic curve. This means that a population starting at some lower asymptotic level in a favorable environment begins to grow exponentially as Malthus supposed, but as it begins to fill up the available space the crowding factor acts adversely on the death rate or on the birth rate or on both so that the growth rate begins to decline long before the upper limit is reached. Finally, when the space-limited environment can support no larger numbers a state of equilibrium is reached at which the birth rate just balances the death rate. This last phase leads to the upper asymptotic value. The population density from then on remains relatively constant, fluctuating about this upper limit. The population of France, for example, has for some years exhibited this last phase of the cycle.

Evidently it is theoretically possible, and sometimes appears in fact to be the case, that a population may remain relatively stable at the same asymptotic level for a long period of time, and then begin active growth again on a new logistic cycle. What causes this new growth then? Obviously an external environmental change for the better is necessary and this means in effect an enlargement of the environment. In a human population some new means of economic production or distribution may act in this way. The population of Japan, for example, is thought to have remained at a constant level, possibly for centuries, before it began the logistic cycle of growth caused by the industrial revolution when it was brought in contact with Western civilization. Opening up of new territory can have the same effect, which can be felt even though there is little emigration to the new lands. On the other hand, when a group of individuals actually migrates to virgin territory, there is in no true sense any lower asymptotic population level though for purposes of curve fitting one may be assumed and its value taken as the original number of immigrants. This latter situation is probably not uncommon in nature and may be accurately duplicated in the laboratory.

Other approximations to the natural conditions are not so easy to reproduce experimentally. Malthus based his theory of population growth on the assumption that reproduction proceeds by geometric progression while the means of subsistence increase arithmetically. Energy is used up by vital activity and must somehow be replaced or the population will necessarily decline and finally become extinct. In nature, this energy is added at a relatively constant rate from the sun through the green plants. This condition is admirably copied in a balanced aqua-

rium. But as such a symbiotic relationship has not been created in most quantitative population experiments they are not comparable to natural conditions in that respect. As has been mentioned, protozoan populations grow logistically, but, if left in the same culture medium, instead of maintaining an asymptotic level they decline rapidly and finally all encyst or become extinct—the energy flowing in one direction only, the reaction must go to an end. *Tribolium* populations eat their available food supply very slowly, so Chapman found them fluctuating about an asymptotic level for a while but Park showed that eventually they too became extinct if left indefinitely in the same flour. The final decline of such an experimental population does not in itself seriously interfere with comparing the growth period with that of balanced populations, but the lack of an added constant increment of energy undoubtedly has some effect on the growth curve before the upper limit is reached. In this respect, *Drosophila* has a great advantage for population work. Since it is in partial symbiosis with the yeast which is its principal food, the growth of the yeast produces just such an added increment of nourishment (until the food dries out) as is lacking in the case of protozoan and *Tribolium* populations. Of course, many insects naturally live in environmental conditions which are continually running down, requiring them to find a new source of food for continued existence.

L'Heritier and Teissier (1933) set up an environment for *Drosophila* which met all the requirements and beautifully tested this part of the theory. Ten *Drosophila*, 5 males and 5 females, were placed in a large cage. Each day a saucer of food was put in the cage and was removed at the end of twenty days when all the food had dried up. In other words, there was

one saucer in the cage the first day, two the second day, three the third day and so on until the twentieth day after which time the number remained constant since the oldest saucer was removed and a new one added each day. The food supply thus never diminished and a constant increment of energy was added to the system each day. Two such experiments were run, and in each a state of equilibrium was reached by about the fortieth day with about 3,200 flies per cage as the asymptotic value. In one series there were 3,200 flies on the 38th day, 3,310 on the 50th day, and 3,290 on the 65th day; in the other series there were 3,010 flies on the 38th day, 3,290 on the 45th and 3,270 on the 51st day. The authors say that judging from the number of pupa cases about 141 imagoes emerged each day, after equilibrium was established, so that the average duration of adult life must have been about 23.3 days. At the last census of the two populations, 34 percent were males and 66 percent females.

c. Duration of life and time of development

The two primary factors producing the growth curve are the rate at which the imagoes emerge from the pupa cases (corresponding to the birth rate of a human population) and the death rate, or, inversely, the length of life. Pearl and Parker (1921) started a long series of investigations on the latter factor, entitled "Experimental studies on the duration of life," by publishing life tables for *Drosophila melanogaster*. More extensive tables were put out three years later (Pearl and Parker, 1924a). Pearl (1922) and Pearl and Doering (1923) compared the life span of *Drosophila* with that of man and of the rotifer *Proales decipiens* by plotting the number of survivors of an original population of 1,000 individuals (loga-

rithmic scale) against the centiles of life span (arithmetic scale) thus putting the life span of all three animals on the same scale. It was found that "at each centile age throughout the life span the number of survivors starting life together, is higher in man than in *Drosophila*." This means, that man more nearly approaches the situation of all the individuals living to the same age then all dying at once than does *Drosophila*. *Proales* approaches this condition considerably more closely so its survivorship—centiles of life span curve—is more nearly rectangular than the others. The curve for the females of one long-wing wild stock was almost indistinguishable from the human curves while vestigial flies had quite a different type of curve which approached a straight line. In both stocks, the females were longer-lived than the males. Brownlee (1924) compared the life span of man with that of *Drosophila* using Pearl's data but employing a different statistical technique and arrived at the same conclusions.

Hyde (1913) working with *Drosophila ampelophila* (= *D. melanogaster*) found two inbred strains, one with an average life span of 37 days and the other with a life span of only 21 days. Crossing the two, he found the F_1 hybrids had a life span of 47 days but the F_2 generation dropped to an average of 29.5 days. An interesting point was that in both original stocks the males had a considerably longer duration of life than the females. Pearl and Parker (1922a) took up the study of the inheritance of the duration of life in *Drosophila* and in the preliminary study concluded:

"A. That there exists in a general population of *Drosophila melanogaster* (or its mutants) genetic differences in respect to duration of life."

"B. That these genetic differences are capable of isolation, by appropriate selection and inbreeding."

"C. That within an even moderately inbred line, the genetic differences in duration of life remain constant over periods of at least 10 to 25 generations or more."

Pearl, Parker, and Gonzalez (1923) crossed a long-lived wild stock with a short-lived vestigial winged mutant stock and found, as Hyde had, that the F_1 offspring had a longer average duration of life than either parent stock. Since the vestigial mutant is a simple recessive characteristic, the F_2 generation aggregated into half long-wing and half-vestigial-wing flies and it was found that the mean duration of life for each type was almost identical to that of the corresponding parent type. Gonzalez (1923) extended this study by working with five different mutant genes of the second chromosome. He found that each of these genes had a definite predictable effect on the duration of life.

In these experiments it was necessary to etherize the flies at the start in order to sex and count them. Pearl and Parker (1922b) therefore tested the effect of etherization on duration of life to see if it was distorting their results. They found that etherizing the flies once, twice, three times or four times at various ages had no appreciable effect on their life span. However, a method of counting the flies without etherization was devised and regularly used in these experiments. A diagram of the tube used for this purpose may be seen on page 275 of Pearl and Parker (1922b) and also on page 30 of *The Biology of Population Growth* (Pearl, 1925). Northrop (1926a) found that an intensity of light of 1,000 meter candles or more shortened the duration of imago life and that in general the rate of aging is proportional to the intensity of light to which the imagoes are exposed. Alpatov and Pearl (1929) studied the influence of temperature. *D. melanogaster* reared (egg

to imago) at 18°C. are larger than those reared at 28°C. and live somewhat longer. The duration of life decreases with rise in temperature over this range and whereas the females always live much longer than the males this difference diminishes with increasing temperature. Loeb and Northrop (1917) also showed that with increased temperature (within the normal range of temperature) the various developmental stages were passed more rapidly and the duration of imago life was shortened. But below 15°C. the life span was again greatly shortened for the stock they used. Studying the nutritional effect, Alpatov (1930) removed larvae from the food before the normal time for pupation and the imagoes which developed from them were small but did not have their life span significantly shortened. On the other hand, normal flies died sooner if given no yeast during adult life. Pearl and Parker (1924b) completely starved flies in the adult stage and the life span was greatly shortened. The survivorship curves for the starved flies were rectangular in form since all the flies tended to die at about the same time. The females still lived longer than the males. Pearl and Parker (1922d) wanted to see if a generalized growth hormone affecting the rate of living might not be found in developing animals. For this purpose they added "embryonic juice" from chicks and from *Drosophila* larvae daily to the food of adult flies, but found no effect upon their duration of life. Northrop (1917b) put sterile eggs on sterile banana and added yeast immediately, or 1, 2, 3, 4, . . . 11, or 12 days later. When the imagoes emerged they were kept on sterile agar-glucose medium (starvation conditions). The later the yeast was added the longer the larval period lasted, and it could be prolonged over 100 percent in this way. When

yeast was added immediately, the total span was 19.3 days; when added at the end of 8 days the life span was 25.5 days and when added at the end of 100 days the total life span was 28.9 days. But the imago period remained constant between 10.9 and 11.9 days in any case. This showed, according to Northrop, that "the relative duration of life of each of the three stages is independent of that of the other two stages."

The most interesting of these studies in relation to the present paper was the determination of the effect of adult population density on the duration of adult life by Pearl and Parker (1922c and 1923) and Pearl, Miner, and Parker (1927). In the basic experiment the flies, just a few hours old, were placed in one-ounce glass vials with banana-agar medium seeded with a standard amount of powdered yeast. The vials were closed with cotton plugs permitting circulation of air. Each day the flies were changed to a new vial and any dead flies counted (but not replaced). Two, 4, 6, 8 . . . 125, 150, and 200 flies (twenty steps in all) were initially placed in each vial, there being a total of 530 vials and 13,000 flies in all. As was to be expected, the higher densities considerably shortened the duration of life but the more significant point was that up to a density of between 30 and 55 flies per vial at the start *increasing density significantly prolonged the duration of life*. The statistical work required for this investigation matched the experimental in laboriousness as the crowding factor was calculated separately for each fly as the mean density to which it was exposed throughout its life. Further studies showed that densities above 200 flies per bottle at the start had little further effect in reducing the duration of life. In other experiments, flies were started in high and in low densities and then changed to

the opposite condition after the sixteenth day of life. It was found that crowding has the most marked effect on mortality in early life. Flies which survived densely crowded conditions in early life were nevertheless weakened so that when they were transferred to an uncrowded environment they did not live as long as they would have, had they never been crowded. The general effect of crowding on wild type *D. melanogaster*, then, is to convert "the normal life curve characteristic of the wild-type flies into the diagonal type of curve, with its short absolute duration of life characteristics of vestigial flies at optimal densities of population" (Pearl, 1928, page 147).

The principal work on the duration of life, as just described, was carried on with imagoes but some odd bits of information are available about the growth rate and time required for other stages. Alpatov (1929) did the principal work in this line. He found that in wild type *D. melanogaster*, at 28°C. the majority of eggs hatched in 18 to 24 hours after oviposition. Using a technique of fixation with boiling water he was able to measure samples of larvae at intervals and publish growth curves for them. In general it has been found that the better the feeding the sooner the larvae will pupate and the imagoes emerge. Krafka (1920) found that the imagoes emerge a day earlier when the larvae are fed on Fleischman's yeast than when raised on bananas and that when the food was so dried out that they could just survive, the imagoes emerged about 5 days later than the controls in good food. Northrop (1917a and b) (as has been described) showed that lack of yeast prolonged the larval period. Eigenbrodt (1925) found that flies emerge later from bottles in which the parents were crowded, which might be a food effect. On the other hand, Alpatov (1930) par-

tially starved larvae by removing them from the food medium to plain agar 48 hours after the eggs hatched and found that these larvae pupated earlier than controls kept on food. All workers have found that, within the normal range, the higher the temperature the sooner the larvae develop. Bergner (1928) prolonged the larval period by low temperature and by poor feeding and found the rate of crossing-over was increased by the treatment. Bonnier (1926), using a sex-linked mutant yellow stock, observed his culture bottles every two hours and removed each pupa formed during the preceding period to a separate bottle and later observed these bottles every two hours while the imagoes were emerging. His results were as follows:

| | AT 25° C. | | AT 30° C. | |
|---|------------|------------|------------|-----------|
| | Males | Females | Males | Females |
| Hours, egg laying until pupation..... | 116.78±.20 | 116.62±.19 | 103.37±.43 | 99.95±.49 |
| Hours, pupation to emergence of imago. | 115.43±.23 | 111.36±.25 | 84.26±.34 | 78.15±.50 |

High temperature speeded up development in both larval and pupal periods. At 30°C. the females developed significantly faster than the males in both the larval and the pupal stages. At 25°C. the pupal period was significantly shorter for the males than for the females (difference 4.1 hours), but there was no significant difference in the larval period. Stanley (1935) found that wild flies emerge sooner than vestigials while the heterozygous F_1 generation flies are in between but more nearly like the wild type than the vestigials in this respect. Bliss (1926) was interested in finding the best end points to use as indications in measuring the rate of development. He

found that there is a diurnal fluctuation in the rate of emergence of the imagoes, the greatest rate being in the early morning hours and the lowest rate being at night. On the other hand, no such rhythm was found in the rate of pupation, and he concluded that it was impractical to use the emergence of the adults as an indicator of the time of development. I am not altogether convinced of the validity of his findings, and certainly when environmental conditions change the time of imago emergence by as much as several days it can be taken as an indicator of development even if there is a slight diurnal fluctuation.

In the case of the two physiological races of *Drosophila pseudoobscura*, Poulson (1934) reports a very much more marked diurnal fluctuation, almost all of the adults emerging in the early morning hours even when kept at constant temperatures in dark incubators.

Pearl (1928) has summed up these experiments on the rate of growth and the duration of life of *Drosophila* and also of canteloup seedlings raised in the dark without food. "All of the evidence presented in this book [*The Rate of Living*] converges to the conclusion that, in general, the duration of life varies inversely as the rate of energy expenditure during its continuance. *In short, the length of life depends inversely on the rate of living.*"

d. Productivity, fecundity and fertility

There has been considerable confusion in the use of terms describing reproductive activity and it is therefore necessary to briefly state how I shall use them before discussing the problem. The word "fertility" has been used by different authors to mean egg laying, production of sperm, whether or not the eggs hatch, the propor-

tion of eggs which develop into adults, and, finally, the net production of adult offspring. Following the usage of Pearl and Alpatov, I shall use the word *fecundity* when speaking of the number of eggs laid by a female, whether or not the eggs are viable. Males which cannot have offspring and females which lay no eggs will be called *sterile*. The number of adult offspring produced under certain conditions will be called the *net productivity* and the percentage of eggs laid which develop into adults will be called the *percentage emergence* (to avoid confusion with the percentage of eggs which hatch).

Fecundity in *Drosophila* is extremely sensitive to environmental conditions and, as will be shown, genetic factors are quite important. For both these reasons, but more particularly for the former in the case of an inbred stock, there is a great variation in the number of eggs laid by different females and the standard deviation of the number of eggs laid by the same female from day to day is very large. Besides there is some indication that there may be cycles in fecundity while it very definitely changes with age. Couple with this the fact that one female may produce over one hundred eggs in twenty-four hours and it becomes apparent at once that this is a very difficult characteristic to study. As various workers have used widely different stocks and even different species and no two used exactly the same technique, the arithmetic values obtained can only be used for comparison within the particular set of experiments in which they occurred.

Guyénot (1913) counted the number of eggs laid by females when fed on sterile apple with yeast. He found that they laid many more eggs with the latter food conditions, but unfortunately he used very few flies and his results were not very

conclusive. Pearl, Allen and Penniman (1926) found a considerably higher fecundity with their new synthetic medium than with banana agar. Alpatov (1932) showed that underfeeding of the larvae reduced the fecundity of females developing from them. In a set of preliminary experiments, I found that an apparently very minor variation in the yeast fed to adults would make an immediate effect of more than a hundred percent in the fecundity and that the number of eggs laid on any one day was determined to a high degree by the environmental conditions in the few days just preceding. Hyde (1924) says that "egg laying reaction is dependent in no small measure, as is well known, upon the condition of the food." While this must be apparent to anyone doing this work, I do not believe that the degree of sensitivity has been fully appreciated.

Hanson and Ferris (1929) found that mated females lay 50 to 100 percent more eggs than unmated females. This increased egg production was produced to the same degree when the females were mated to sterile males as when they were mated to fertile males. Shapiro (1932) found that mated *Drosophila melanogaster* begin egg laying one or two days after emergence while virgins sometimes do not begin to lay eggs until the seventh day.

Alpatov (1932) developed a new and very convenient method of testing fecundity, a diagram of which may be seen on page 72 of Pearl (1932). The food is put in a watch crystal which is held in place in the mouth of a one-half pint milk bottle by two small pieces of plasticine. The bottle is then turned upside down and kept at a constant temperature. Each day the watch crystal is removed, the number of eggs laid on the food counted and another crystal with fresh food put in the mouth of the bottle. Experience

has proven that the flies will lay all their eggs on the food and not elsewhere. Using this technique, he studied the daily egg production curve and the total egg production for *D. melanogaster* females during their entire adult life. He found that flies bred at low temperatures produced more eggs than flies bred at high temperatures, the temperature during adult life being the same in both cases, and that underfeeding as larvae decreased the later egg production as adults. Vestigial-winged flies were found to have a much lower fecundity than normal wild flies. A point of considerable interest was that a negative correlation was found between the duration of adult life and the average egg production per day for the whole producing period, a fact which fits in well with Pearl's rate of living theory.

Hyde (1924) noted: "It is, moreover, a curious fact that the average output of eggs for each female is greatly reduced when she is subjected to mass culture." Pearl, Allen, and Penniman (1926), in testing the effect of this new synthetic medium, placed 1, 2, 4, 8, 16, and 32 pairs of *D. melanogaster* in a series of half-pint stock bottles, removed them at the end of eight days, and counted the offspring. The total reproductivity was the greatest in the bottles with two and with four pairs of parents. The mean net productivity per female per day, however, was greatest with one pair of parents per bottle and dropped steadily with each increase in density. These results might have been due to decreasing viability of the eggs with higher densities, an increasing larval and pupal mortality, reduction in fecundity or all three combined. Of the three, the latter was probably the most important as Pearl's later experiments showed. Pearl and Parker (1922a) did a more extensive experiment of the same kind, studying

the net productivity per day for mated females at different densities of population for the first sixteen days of life. They found that the rate of reproduction varies inversely with density of population according to the formula $\log y = a - bx - c \log x$, where y = the net productivity per mated female per day and x = the mean density of population. MacLagan (1932) fitted Farr's formula to Pearl's *Drosophila* data and to Chapman's data on *Tribolium*. This formula states $\log y = \log a + b \log x$, where y = the number of progeny and x the space per individual. The formula given by Pearl and Parker is an inverted form of the same equation. Pearl (1932) did the major experiments of this series in finding the exact relationship between fecundity and population density, in the course of which a total count of over 100,000 eggs was made. Egg counts were made daily at densities ranging from 2 to 256 flies per bottle, in both half-pint and quarter-pint bottles. The change of rate in egg production was found to be described by the same type of mathematical equation as that which relates mean free path of molecules to density in a gas. It is probable that this was due primarily to the collision rate and general mechanical interference of the flies with each other which presumably increased with increasing density of population. The food area was the same in the half-pint as in the quarter-pint bottles and a comparison of the egg production for the two at various densities shows that density of population is principally a matter of the number of flies per unit area of food rather than the number of flies per unit of air volume. A series of experiments in which the same flies were daily alternated between crowded and uncrowded conditions showed that the crowding factor was immediately expressed in terms of fecundity.

So far as I can find, Duncan (1930) is the only worker who has studied the reproductive capacity of the male of *Drosophila melanogaster*. He found that an 18-day old male would mate with fertile results about once every 20.8 minutes when not disturbed. Experiments were then run in which the male was put with a new virgin female following each copulation and the total number of offspring produced by all these females counted. This treatment slowed down the rate of copulation considerably but the results give a fair idea of the range, at least, of reproductive capacity. Of the ten males tested, the most productive had 14,070 offspring and the least productive had 7,368 offspring (imagoes). The average male was fertile for about 32 days and within limits, it did not matter whether he was first mated when quite young or when quite old. For example, one male was not mated until he was 57 days old and yet remained fertile for 31 days. The fertility (or the rate of net productivity) was highest in the first five days of mating and then dropped steadily, almost in a straight line, up to the end of the fertile period. It would look as though each male has a definite capacity for sperm production which may be used up either quickly or slowly. There was some indication that large males can produce a greater number of offspring than small males. As compared with the male capacity to produce great numbers of spermatozoa, Hyde (1921) reported on three *D. melanogaster* females, A, B, and C, with especially high fecundity records, which produced 2,184, 1,613, and 1,807 eggs respectively for A, B, and C. Female A often produced her own weight in eggs during twenty-four hours and for her whole life span she laid on the average her own weight in eggs every forty-eight hours. In all, she laid 32 times her own

weight in fresh eggs, or comparing the dry weight of the eggs with the dry weight of the fly, she laid 80 times her own weight in eggs.

Moenkhaus (1911) working with *D. ampelophila* found great variations in the number of sterile individuals found in different stocks. Some strains of flies were from 20 to 48 percent sterile while others were 100 percent fertile. He says the inbreeding had little effect upon the proportion of sterile individuals. Wentworth (1913) inbred four pure lines originating from a single pair of orange-eyed mutant flies basing the original selection on size and apparent vigor, and found that the productivity was somewhat different for each and bred quite true to type. His experiment does not show how much of this difference was due to sterile individuals, non-viable eggs, and larval mortality. The net productivity dropped with inbreeding.

Hyde (1913) commenced a large scale series of experiments on the inheritance of fertility, sterility, and fecundity in *Drosophila ampelophila*. Egg laying commences when the females are two or three days old. Hybrid flies had much higher productivity than either parent strain, this being accounted for entirely by a great increase in fecundity with hybridization since the percentage emergence was less than in pure strains. Hyde (1914a) found an inherited defect in the female which prevents oviposition and results in sterility (in the female only). It is carried both by males and females, in which it does not appear phenotypically, so acts like a sex-limited Mendelian recessive although the exact mode of inheritance was not determined. The same worker (Hyde, 1914b), found a very low producing inbred truncate stock which he crossed to a high producing wild stock. Wild females mated to truncate males and truncate

females to wild males both had a higher net productivity than females of the corresponding types mated to males of the same type. Brother-sister matings were made up from F_1 hybrids of both reciprocal crosses and they were equally found to be very high producers. The F_2 generations, however, were much smaller producers. A further experiment showed that while the inbred wild stock had about a 75 percent emergence, only one-fifth to one-quarter of the eggs from truncate females mated to truncate males developed into imagoes (20 to 25 percent emergence).

On the other hand, when a truncate female was mated to a wild male, many more of her eggs developed. This accounts for the rise in net productivity with the original cross. The F_1 hybrids crossed brother-sister had a percentage emergence of only 56.6 percent, but a very high egg production, so the net productivity was still higher than the wild type parent stock. Hyde (1914c) further tested the effect of crossing on percentage emergence under two conditions (a) by inbreeding different lines from the same original pairs and later crossing the two lines, (b) by crossing wild stocks from different regions. In the first case, he found that some of the lines from the same progenitor went down in percentage emergence while others did not; on crossing, the offspring were brought up to the level of the higher percentage emergence line. Crossing wild stocks from different sources in some cases brought the percentage emergence just up to the level of the better stock and in other cases produced a better percent emergence than that for either original stock. Twenty different wild stocks taken from various regions were found to have a percentage emergence varying from 80 to 100 percent (Hyde, 1917) while on inbreeding it

dropped to as low as 25 percent. Hyde concluded that inbreeding does not necessarily lower the percentage emergence but its effect depends upon how the genes happen to be selected and combined and likewise the same factor determines whether or not the percentage emergence will be raised by crossing. That is, "inbreeding gives a chance for defects to be brought to the surface" and "low fertility is likely to accompany close inbreeding provided it is not accompanied by rigorous selection." Fecundity, on the other hand, did not decline with inbreeding (Hyde, 1919) and the correlation between the fecundity of the female and the percentage of the eggs which develop into imagoes is very low. Hyde (1924) extended these experiments and this time found that the percentage emergence for wild stocks taken in different localities varies from 67 to 96 percent, most stocks being between 80 and 90 percent. On inbreeding, the percentage emergence of these same stocks dropped to 24 to 84 percent with most of them having a percentage emergence between 45 and 75 percent. Carver (1937) obtained similar results; crosses between wild and vestigial stocks and between wild and hairy stocks gave a higher net productivity than when flies of any one type were mated to flies of the same type.

The inheritance of egg size, a characteristic which is perhaps closely associated with fecundity, has been studied by Warren (1924). Various different stocks were found to have characteristic and constant ranges for egg length. When two stocks with different egg lengths were crossed, the F_1 heterozygous females almost invariably laid eggs intermediate in size between those for the two parent stocks. The largest eggs were found in an abrupt stock (average length .522 mm. based on the measurement of 1,000 eggs)

while a bar-eyed stock had the shortest average egg length found (.445 mm.). The length of the eggs produced by a single female varied slightly from day to day but egg length did not vary with either the size or the age of the females and was not affected by temperature.

e. Effect of the environment on the individual and on the genetic ratio

There is no older or more bitter argument in the realm of science than that relating to the relative importance of heredity and environment. It still rages with unabated violence in popular discussions but biologists, tiring of the fight, called a truce some years back after the retreat of the Lamarckians and were willing to let it go with saying that both are important. Obviously, in an inbred, genetically constant stock all the differences between individuals are to be accounted for by environmental influences while in a constant environment with a mixed stock all the differences between individuals are to be attributed to varied inheritance (unless someone can think of a third factor outside the realm of cause and effect). So, to eliminate undesired variables, the geneticists have based all their conclusions on animals raised under nearly optimal environmental conditions while physiologists like to work with animals of inbred, genetically constant stocks.

Recently, however, to an increasing extent workers have begun to attack this problem, which is of fundamental biological importance, by quantitative methods which are yielding tangible results. *Drosophila* is an ideal animal for this since so much is known of its genetic constitution and at the same time it is so sensitive to environmental influences. The papers just reviewed show how profoundly such physiological characteristics

as fecundity, fertility, longevity, and speed of development are influenced by both factors. An experiment by Dobzhansky (1935) strikingly illustrates the problem and the need for further work along the same lines. There are two races, A and B, of *D. pseudoobscura* alike morphologically, but not interfertile with each other. Race B is said to be found most frequently in cool, moist, equable climates, while race A inhabits areas with warmer and more variable climatic conditions. Dobzhansky found that females of race A produce more eggs than those of race B at 25° and 27.5°C. while females of race B produce more eggs than those of race A at 9°, 14°, and 19°C. It seems probable that there is some temperature between 19° and 25° at which females of races A and B lay the same number of eggs. At this temperature no genetical difference would appear. Clearly, a single, constant environment would not suffice for a genetic study in a case like this. It is necessary to have a quantitative comparison of the effect of both variables (hereditary and environmental) in order to understand the distribution and competition of the two races in nature. Another illustration, of a rather different sort, might be cited from a paper by Morgan (1912). A simple Mendelian sex-linked dominant mutation called "abnormal abdomen" turned up in a wild stock of *Drosophila* and behaved perfectly normally in inheritance when the food conditions were good. But in old cultures, or when the larvae developed in dried-out food, flies with this mutant gene showed no evidence of it phenotypically. That these flies actually carried the gene was demonstrated by the fact that their offspring developed the abnormality if raised in good culture conditions. Braun (1938) has just described the effect of environmental conditions upon the manifestation of a new

recessive, autosomal gene, a-III (according to Schaeffer in chromosome III, near sepia) which produces an abnormal phenotype very similar to Morgan's "abnormal abdomen." In this case, however, dry food, old food, too little food, and overcrowded stocks favor the phenotypical expression of this gene.

Neel (1937) reports a sex-limited mutation, evaginated, in the male only of *Drosophila funebris* which is influenced by environmental conditions in much the same way. In good cultures it may appear in only 5 to 10 percent of the males carrying it genetically while it appears phenotypically with a much greater frequency in poor culture conditions and at high temperatures.

A considerable amount of work has been done by Driver (1931), Baron (1935), Luce (1935) and others on the facet number of the bar-eyed mutant of *Drosophila melanogaster* as affected by temperature. The facet number varies inversely with temperature during development but more particularly so above 21° which seems to be a critical point. There is only a certain period of development at which the temperature has this effect, however. The lower the temperature the longer is the larval period so the longer the "temperature effective" period lasts in days; it is also relatively somewhat longer at low temperatures. This "temperature effective period" falls within the third larval instar according to Driver. An eyeless or nearly eyeless condition occurs in some bar mutants and in these stocks the proportion of such individuals increases with rising temperature. Baron thinks this may be due partly to a selective death rate.

Alpatov and Pearl (1929) noted that flies developing at 18°C. are larger than those developing at 28°C. and Alpatov (1932) showed that both the length and

width measurements of the wings of wild-type flies were smaller if the larvae were underfed or raised at a high temperature. Imai (1933) found that, whereas the wing measurements are always greater in the female than in the male, this difference is most marked at higher temperatures. He also found that length of the femur of all three legs decreases with rise in temperature but that there is comparatively little difference between the sexes and this difference does not increase with rising temperature. Harnly (1930) discovered that in vestigial *Drosophila melanogaster* males a rise in temperature from 18.3°C. to 29.0°C. produced a very slight *lengthening* of the wings; between 29°C. and 30°C. the wings increase 25 per cent in length, and from 30°C. to 31°C. they increase 70 percent in length. His figures for male and female wing lengths of vestigial flies are given below:

| TEMPERATURE DURING DEVELOPMENT | WING LENGTH, MALES | WING LENGTH, FEMALES |
|--------------------------------|--------------------|----------------------|
| 18.3°C. | .64 ± .0026 mm. | .61 ± .0024 mm. |
| 29.0°C. | .74 ± .0030 mm. | .74 ± .0023 mm. |
| 30.0°C. | 1.00 ± .0099 mm. | .79 ± .0037 mm. |
| 31.0°C. | 1.70 ± .0114 mm. | 1.12 ± .0209 mm. |

It may be noted from the above table that the wings of the males begin to be greatly affected by temperature starting at 29°C. while the wings of females are not greatly affected until a temperature of 30°C. is reached. The opposite behavior of wild and vestigial flies in respect to wing length with rising temperature may indicate an effect of this gene more profound than its determination of the type of wing. Hersh and Ward (1932) found that heterozygous wild-vestigial flies behave more like wild flies than like vestigial flies in respect to the effect of temperature on wing size. Those with long-wing mothers and vestigial-wing

fathers have larger wings, on the average, at all temperatures than those of the reciprocal cross. Harnly and Harnly (1935) found a recessive sex-linked gene modifier (dimorphous), for the gene vestigial which affects wing and eye size. At 25°C. it shows in the male only, but above this temperature it shows in both sexes. In the temperature range from 16°C. to 32°C. all variations in wing type are found in the male ranging from vestigial wings (at low temperatures) to normal long-wings at high temperatures. The wings of vestigial males with this gene are larger than those of females with the gene at all temperatures up to 32°C. at which point the wings of the two sexes are the same size.

Eigenbrodt (1930) found that in a homologous bar-eyed stock of *Drosophila melanogaster* the body weight, thorax length, and head width all vary inversely with temperature, these relationships plotting very nearly as straight lines between 17°C. and 29.5°C. He, too, found that wing length and width vary inversely with temperature, but more markedly so in the lower temperature range. Temperature not only changes the size of the flies but their bodily proportions also, since the correlation coefficient of wing length-thorax length varies directly with temperature.

Plunkett (1926) found that the number of bristles varied inversely with temperature in a range from 14°C. to 30°C. in his stock of *Drosophila melanogaster*. At any temperature, the more flies which emerged per bottle, the fewer were the average number of bristles per fly. Eigenbrodt (1925) obtained what he considered to be crowded larval conditions by leaving 5 pairs of parents in 8-dram culture vials for six days at 27°C. (or 9 days at 17°C.). Those emerging from these vials had fewer hairs, fewer teeth in the sex comb

and greater uniformity in size than flies from uncrowded vials and they took longer to develop.

The factors just discussed all have a direct effect upon the phenotypical expression of certain genes. On the other hand, a selective death rate in the larval and pupal periods may upset the expected genetic ratios of the imagoes which do emerge without altering the character of the individuals which survive.

Mann (1923) treated an inbred stock of *Drosophila melanogaster* with a great variety of semi-poisonous substances (arsenic, quinine, lead acetate, methylene blue, lithium carbonate, etc.) in the hope of obtaining mutations, but only got one mutation to 15,000 flies as compared with one mutation to 23,000 flies in the normally fed controls. A probable explanation would seem to be that as most mutants are weaker than the wild type, those which occurred in the poisoned food ran a greater risk of being killed in the larval stage and so a smaller percentage were seen as adults.

Morgan and Tice (1934) said that crowding caused less than the expected number of rudimentary wing and strap-wing flies to appear in crosses. Remarkable on the divergence of expected from observed ratios in genetical work with *Drosophila*, Bridges (1921) says that "... overcrowding was the largest source of disturbance in most of the early work as well as in some of the later." Under the most optimal food conditions they could devise, Harnly and Harnly (1929) could obtain only 0.9 vestigials to 1.0 long-wing flies in a back-cross of vestigials to heterozygous flies (the expected ratio was 1.0 to 1.0 since the gene vestigial is a simple recessive). Better culture conditions gave a greater total productivity of both types. When small vials were used the divergence was much greater, while

reducing the time the parents were left in the bottles gave nearer to the expected ratios, so the authors concluded that a selective larval rate which increased with crowding was the cause. Clausen (1924) backcrossed black cinnabar vestigial males to heterozygous females in half-pint bottles with single pair matings and obtained the expected 1 to 1 ratio of offspring. He says that he made such matings in six small vials with three pairs of parents to each vial and obtained less than the expected number of offspring of the recessive type. This he thought was due to larval crowding and consequent selective mortality.

3. OTHER INSECTS, ETC.

While *Tribolium* and *Drosophila* are the only two insects whose population physiology has been thoroughly studied, there has been some experimental work done on other insect and crustacean populations. Norris (1936) has studied longevity and fecundity in another flour beetle, *Trogoderma versicolor*. As adults the males live about eleven days and the females live about twenty days and lay somewhat over a hundred eggs in all. When these adult beetles are put in empty dishes and given neither food nor water, they live just as long and lay just as many eggs as when food and water are available. The feeding during the larval stage, however, makes a considerable difference in the fecundity. The total number of eggs laid by females was as follows: whole wheat flour, 104 eggs; oatmeal, 105 eggs; maize flour, 83 eggs; and wheat flour, 67 eggs. Norris (1933) has also studied the Phycitid moth, *Ephestia kuehniella*, which lives in flour during the larval period. Its reactions are very similar to those of the beetle, *Trogoderma*, and it is cultured in exactly the same way. No food or water

is required by the adults, while poor food or an abnormally small amount of food during the larval period reduces fecundity. Virgin females produce no eggs. The fault for unsuccessful mating lies with the male, according to Norris. When reared at 27°C. from 10 to 59 percent of the matings are completely unsuccessful (and no eggs are laid) and when reared at 30°C., 96 to 100 percent are unsuccessful, but high temperature (30°C.) does not disturb mating if the moths are exposed to it during the adult period only. Moths reared in crowded bottles have more unsuccessful matings than those reared in uncrowded conditions.

Maclagan (1932) reviewed Pearl's work on *Drosophila* and Chapman's work on *Tribolium* and became particularly interested in the effect of population density on fecundity. His question was whether crowding (that is, number of animals per unit volume) has a direct effect in itself or whether it is simply an effect of available food supply. The grain weevil, *Calandra granaris*, can be cultured in a bottle of whole wheat grains and, calculating the population density in terms of grains per animal, Maclagan found an optimal density for reproduction (that is crowding up to a certain point gave a higher rate of reproduction than no crowding). He then mixed wheat grains with an equal number of small glass beads of about the same size and in this way doubled the volume without increasing the food supply. Weevils placed in this mixture at a certain population density had exactly the same reproductive rate as those placed in wheat grains alone at twice the density per unit volume. Thus the reproductive rate was controlled by the number of grains of food which was the same in both cases and was unaffected by the space relationship.

Larson and Fisher (1924) worked with

the cowpea weevil, *Brachus quadrimaculatus* Fab. This insect may live for a considerable period and lay many eggs without having either food or water. He found that access to water alone increased the life span by about 10 days while a diet of sugar-water greatly increased the longevity. An interesting fact was that feeding reduced the fecundity of females for the first few days, though they laid more eggs all told than starved females since they lived so much longer. This is what might be expected from Pearl's rate of living theory. Virgin females produce only a few eggs, none of which are viable.

Glaser (1923) raised house flies (*Musca domestica*) and biting stable flies (*Stomoxys calcitrans*) in horse manure and kept the adults in bottles with a food solution (horse blood serum or bouillon or egg white, etc.) placed on a gauze stopper in the mouth of the bottle. The type of adult feeding was found to have a great influence on both longevity and fecundity (the better the food the higher the fecundity and the greater the longevity). Mated females of both species laid more eggs than unmated females. Cattle horn flies (*Lyperosia irritans*) were reared successfully in cow dung from eggs laid by gravid females removed from cattle, but the flies thus reared would lay no eggs.

Miastor metralans is a dipteran which ordinarily reproduces paedogenetically in autumn, winter, and spring but in early summer pupae occur which give rise to male and female imagoes. Harris (1923) reared these animals in the laboratory on a malt agar medium in Petri dishes and found that pupa-larvae occur in old and crowded cultures. He therefore concluded that crowding, or more likely the accumulation of waste products as the result of crowding, is the ordinary stimu-

lation agent for the production of the sexual forms.

Holdaway and Smith (1932) worked with *Alysia manducator*, a small insect which lays its eggs in the larvae of the blow-fly, only one egg per larva as a rule. They plotted the sex ratio of the emerging parasites against the size of the host puparia, and found a high correlation between small puparia and a high proportion of males.

Trichogramma evanescens is a small chalcid fly (order Hymenoptera) which lays its eggs inside the eggs of other insects (usually moths). The female will avoid laying more than one of her eggs in the egg of a host. However, under crowded conditions or when few host eggs are available, two, three, or four *Trichogramma* eggs may be placed in one host egg. When three or more eggs are laid in one host egg, Salt (1936) calls them "superparasitized." In such cases the larvae have to compete for food and usually only one emerges as an adult. The "visitors" are small, weak, and sometimes deformed and the greater the amount of superparasitism the greater is the percentage of male emergents. Thus crowding of the adult parasite population increases the amount of superparasitism and results in greater proportion of males in the following generation.

The population physiology of *Moina* and *Daphnia*, two genera of the order Cladocera, sub-class Branchiopoda, has been studied by several workers. These are little water fleas found all over the world in lakes, ponds, and small temporary bodies of fresh water. Under good conditions they reproduce by diploid parthenogenesis, no sexual eggs and no males being formed; sexually produced winter eggs carry the species over winter, droughts and other unfavorable periods. Banta and Brown (1929a) showed with

Moina macrocopa that crowding the mothers caused them to produce male offspring. A single female alone in a bottle rarely ever produces a male offspring while ten females in 75 cc. of medium produce about 42 percent male offspring. The amount of food present made little difference and the authors thought that excretory products in the culture medium were responsible for the production of males. Other species of Cladocera and other aquatic animals placed with the *Moina* females acted in this respect just as effectively in crowding as having a greater number of *Moina* themselves.

Whatever is the factor in the waste-products which is responsible for the production of males, it is apparently non-volatile but easily broken down by evaporation or allowing the medium to stand idle for some time (Banta and Brown, 1929b). Banta and Brown (1929c) report that the development of the mothers is retarded by crowding and by accumulated excretory products and that this is closely associated with the production of male offspring.

Light doses of ethyl alcohol, filtrates of dried adrenal cortex, thyroid, thymus, and muscle tissue all accelerated the rate of development of *M. macrocopa* mothers (Banta and Brown, 1929d). If they are crowded, the addition of any one of these substances to the medium tends to counteract the ordinary effects of crowding, so less males are formed. This would seem to indicate that the food concentration is more important than the presence or absence of excretory products. A retardation in the rate of development of the mothers was accomplished by Banta and Brown (1930) by treating them with either choloretone, phenyl urethane, or potassium cyanide and mothers so retarded produced more than the normal percentage of males in their first broods of young.

The temperature effect on male production of moderately and densely crowded mothers is rather puzzling (Brown and Banta, 1932). From 14° to 21°C. and above 30°C. the greater the crowding of the mothers the greater the percentage of male offspring. But below 14°C. and between 21°C. and 30°C. the greatest production of males occurs where the mothers are only moderately crowded. In other words, between 21°C. and 30°C. and below 14°C. there is an optimal density (neither the highest nor the lowest degree of crowding) for male production while at other temperatures no such optimal point appears. Brown and Banta (1935) placed two young *Moina* mothers in 75, 50, 30, 20, 10, 7.5, and 2.5 millimeters of culture medium and cultures of each volume were made up with 1/15, 1/25, 1/50, and 1/100 concentration of a standard bacterial suspension (the bacteria serves as food for the *Moina*). The average total production of young per female varied inversely with the food concentration; the volume being constant, while the food concentration had little effect on the sex ratio. But the volume had a great deal to do with the sex ratio (14.2 percent males produced in 75 ml. and 60.6 percent males produced in 2.5 ml. of medium) and the volume also had a great effect upon the total number of offspring per female. Banta (1937) has summed up this experimental work and says that observations of these animals in natural ponds confirm the idea that crowding is the normal stimulating factor for male production.

Ingle, Wood, and Banta (1937) raised *Daphnia longispina* on a manure infusion culture medium. Diluting the medium by adding 36 parts of water to one part of normal medium produced starvation effects. Animals starved throughout life lived about 40 percent longer than well-fed animals while animals starved for 11,

14 or 17 instars and then well fed lived still longer. The starved animals are smaller but if normal feeding is given even after the 18th instar they begin to grow rapidly and approach the maximum body length of well-fed animals. Starvation also reduces the number of offspring, but if the animals are first starved, then fed, they begin to reproduce faster than the normal rate and the total production is nearly as great as if they had been well-fed throughout life. Starvation decreases the rate of the heart beat, indicating a slower rate of metabolism. This is all exactly as might have been predicted by the rate of living theory.

MacArthur and Baillie (1929) found that duration of life varied inversely with temperature in *Daphnia magna*. Crowding, lowered temperature and other unfavorable conditions increase male production as in *Moina*.

Fowler (1931) found that groups of *Daphnia* give a mass protection to the individual from such toxic reagents as CaCl_2 , KOH , NaOH , KCl , etc. *Daphnia* living in dilute solutions of KOH and NaOH significantly weakened the concentration of these bases.

SUMMARY

In summarizing this long review of the literature it should be especially remembered that this work was done primarily with animal aggregations held together by lack of space or by attraction to the same environment rather than by social instinct. Those beneficial effects which have been found to result from limited crowding are the direct results of the members present and are not due to any division of labor. Allee and others have pointed out that such elementary benefits probably were a large factor in the original development of the social instinct which

led in time to the evolution of highly integrated societies with specialization and division of labor among the individuals. In organized societies the direct results of crowding may be obscured to some degree and are certainly harder to evaluate, but there is reason to believe that the same fundamental principles still operate. The danger of accumulated waste products is just as real in a crowded human community as in an over-populated drop of hay infusion, though in the former organized activity may eliminate the evil consequences so long as there is no disruption in the smooth functioning of the society.

On the credit side of the ledger, it has been shown that in such diverse forms as protozoa, crustaceans, worms, marine and fresh water fish, and amphibians the formation of groups may be a protection against toxic substances dissolved in the liquid medium, the presence of noxious solids, extremes of temperature, and other elements of bad environment. Under certain conditions a group of these animals may bring the medium more nearly to optimal conditions or perhaps contribute some important substance to it and so increase their own rate of growth or reproduction. Increasing population density up to a certain point has been shown to increase the longevity of *Drosophila* and to increase the net rate of reproduction of *Tribolium*.

On the other hand, severe crowding is almost invariably harmful. The accumulation of metabolic waste products in a liquid medium decreases the longevity, growth, and reproductive rate of animals

living in it. A decreased food supply, one of the results of crowding, usually, though not invariably, reduces the rate of reproduction and decreases the size and vitality of the animals. The mechanical disturbance of the individuals in crowded conditions reduces the rate of growth in tadpoles and is a major factor in reducing the fecundity and longevity of *Drosophila*, while the practice of egg eating as well as the bad effects of conditioned flour reduces the net rate of reproduction in crowded *Tribolium* populations.

The population physiology has been worked out in great detail for adult *Drosophila melanogaster* and one or two nearly related species and inherited differences have been studied. Pearl has determined the population growth curve for *Drosophila* and its mutants and has shown how two of its major variables, fecundity and duration of adult life, are directly influenced by crowding as the population grows. L'Heritier and Teissier (1933) have demonstrated a *Drosophila* population in dynamic equilibrium with its environment. Hyde, Pearl and his students, and others have shown in a number of cases how fecundity and fertility may be inherited and the part played by inbreeding, cross-breeding, and selection. Besides all this, a great deal of information is now available on the influence of other environmental factors, particularly temperature, on the speed of development, mortality, fecundity, and morphological characteristics of individuals.

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THE RELATION BETWEEN DIATOMS AND COPEPODS AS A FACTOR IN THE PRODUCTIVITY OF THE SEA

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THE main features of the food-cycle of the sea have been appreciated in a general way for a considerable period. Recently, however, more precise information has been demanded on the exact interrelation of the various organisms depending upon one another for food. These demands have arisen from the discovery that in the case of various economically important animals a failure in a more or less remote link of certain food chains may be responsible for poor production. Accordingly, the whole sequence of events from the penetration of light energy into the water to the growth and distribution of a succession of food organisms must be scrutinized and properly related before the variations in the productivity of the sea can be understood.

One of the essential links in the main food chain of the sea is the copepod group (cf. Clarke, 1934). The traditional impression of copepod production is that it follows and is dependent upon the growth of diatoms. But in attempting to determine more precisely the relations between copepods and diatoms, recent investigators have proposed certain widely differing theories, all of which need confirmation. A comparison of these theories and of the plankton investigations from which they emanate, will be valuable and, it is hoped, helpful in penetrating further into this important problem.

The season sequence of biological events in the Clyde Sea area has been clearly demonstrated by the work of Marshall, Nicholls, and Orr (1934). These investigators studied the time of appearance and the duration of the diatom flowerings and observed the production of successive generations of copepods. In the case of the copepod, *Calanus finmarchicus*, spawning took place at four periods during the year, namely in March, April, May, and July. Three of these spawning periods coincided roughly with times of diatom maxima in this region. The young of the broods originating in these periods grew successfully to maturity, but the brood which was spawned in April, at a time of diatom scarcity, failed to develop. From this, Marshall, Nicholls, and Orr conclude that the presence or absence of diatoms at the critical period of the early life of the copepod means the success or failure of the brood.

In similar investigations off the coast of Norway, Jacob Sømme (*in litt.*) has not found substantiation for this view. On one occasion he observed that the zooplankton, which usually accompanied or followed the spring flowering of diatoms in this locality, preceded the appearance of the diatoms by three weeks, and yet production was successful. Similarly, observations undertaken off Woods Hole by Clarke and Zinn (1937), although of a preliminary nature, did not indicate any

necessary dependence of copepod production upon diatom abundance. In our case we found that the two successful spawning periods of *Calanus* occurred at times when the diatoms of the region were at a rather low ebb.

Wimpenny (1936), as a result of a series of observations in the North Sea, regards the presence of the biological conditions which occur within a thick patch of diatoms as particularly important for the successful reproduction of zooplankton. Within his area of investigation he found that the greatest numbers of copepods, particularly *Calanus finmarchicus*, were located between the diatom patches—or at least in no relation to them—whereas the eggs of this species were largely concentrated within these patches. Wimpenny points out that the metabolism of the thickly massed plant cells might be expected to produce an environment attractive to animals ready to spawn and favorable for the development of the newly hatched young. (The actuality of this suggestion has not yet been clearly demonstrated, however). In addition, the abundance of nutriment represented by the diatoms themselves might be a necessary circumstance to bring about spawning, and, if a suitable food, would be important for the nourishment of the feebly swimming young. In short, Wimpenny regards patches of diatoms as nurseries for young copepods and feels that the appearance of the diatoms from May to July is responsible for the successful survival of the new broods. The majority of older copepods, however, were to be found outside the diatom zones.

Certain earlier investigators (Johnstone, 1911; Fish, 1925; and Bigelow, 1926) had reported that in their areas, just as in Wimpenny's case, the main copepod population appeared at times and in places in which prominent diatom flowerings were

absent. Renewed interest in this apparent reciprocity of abundance has recently been aroused by the ingenious theories of Harvey and of Hardy. In studying the seasonal succession of events in the English Channel off Plymouth, Harvey and his co-workers (Harvey, Cooper, Lebour, and Russell, 1935) observed that for more than seven months of the year the phytoplankton was consistently scarce during periods when zooplankton was abundant, and vice versa. Harvey presents evidence that the "grazing" of herbivorous plankton animals—chiefly copepods—was sufficient to reduce effectively the number of diatoms present. Some species appeared to eat greatly in excess of their needs when diatoms were abundant. The spring outburst of diatoms was believed limited in quantity and in time by the grazing activity of the zooplankton. According to this theory, then, the copepods are thought of as regulating the plant population.

The theory of Hardy (Hardy and Gunther, 1935), although not irreconcilable with the foregoing, gives quite a different complexion to the relation between copepods and diatoms. Drawing on a large mass of data from his survey of antarctic waters, this investigator suggests that zooplankton definitely avoids areas where phytoplankton is thick. This situation would be brought about if, as Hardy assumes, the upward migration of the zooplankton at night were stopped when a dense diatom population was encountered. For, the animals which occurred under diatom patches, being forced to make a longer daily sojourn in the deeper strata, would be carried away by subsurface currents. As a result of this so-called "animal exclusion," the animals and plants of the plankton would become distributed in alternating communities.

As Hardy has pointed out, both this theory and Harvey's hypothesis may be

in operation simultaneously. The zooplankton may be excluded from the centers of the diatom patches because of negative tropistic reactions, but at the same time the animals may reduce the phytoplankton population through grazing around the edges and bottom of the patches. Even if the diatoms are more or less evenly distributed in a given area at the beginning of the productive season, isolated patches would soon be formed by the feeding of local concentrations of zooplankton. The dominant animal type of the region would impress its pattern upon the phytoplankton by "eating holes in it." The distribution of the other species of animals present would then be brought to conform by the action of the "exclusion" process.

In a criticism of these theories, Steeman Nielsen (1937) has called attention to a number of cases in which large quantities of both zoo- and phytoplankton exist simultaneously throughout a considerable period. Even in those instances where poor zooplankton has been found in rich diatom zones, or vice versa, a simpler explanation is offered by this author, and one which is particularly apropos for our consideration of causes and limitations of production. It is the time element which Steeman Nielsen shows has been overlooked. He points out that when conditions become favorable for phytoplankton production a very rich population may be established in less than ten days. In the case of the zooplankton, however, not only must the animals mature and spawn following the appearance of suitable conditions, but also a much greater interval must be allowed for development—at least a month for the common copepods. By this time the diatom flowering will probably have passed. Thus arises the impression of an inverse relationship between the animal and plant plankton.

A further complication results from the

fact that currents are usually acting on these populations while they are developing. By the time the copepods are fully developed, they may be miles away from the area in which they were spawned. The particularly interesting situation produced by a combination of upwelling and coastal currents off Iceland which is described by Steeman Nielsen, illustrates the necessity for taking the history of the two types of plankton into consideration as well as their distribution at any one time. In general, this investigator concludes that the quantity of zooplankton is directly related to the quantity of phytoplankton, but he emphasizes the fact that because of the slower development of the animals and the effect of currents, a rich growth of diatoms does not necessarily signify the presence in the same locality of an abundant copepod population. The effect of a large phytoplankton production on the zooplankton may appear somewhere else.

This influence of the time element pointed out by Steeman Nielsen is of vital importance, but, in my opinion, its application to the situation has not been carried far enough. An adequate supply of nutrient must be available not only for the maturing parents and for the newly hatched young, but also for each stage of the developing larvae for a considerable time after the spawning period wherever they may drift. In other words, food must be present not alone for the *origination* of the new generation but for its *growth* as well. Careful investigation of the nutritive requirements of copepods has only just begun, but it is reasonable to assume that a considerable supply of food is required at least during the stages in which the animals are increasing in size. Therefore in attempting to explain the distribution of the zooplankton or the success or failure of certain broods on the

basis of nutrition, allowance must be made for the food requirements both during the spawning period and subsequently.

Whether or not food organisms were sufficiently available in any given case could be much more conclusively decided if we knew precisely what food marine copepods eat and how much they need. A review of this subject by Clarke and Gellis (1935) showed that early investigators were divided into those believing that the larger diatoms are the chief source of food and those who feel that other elements of the phytoplankton are more important. Our early experiments at Woods Hole on the nutritive requirements of copepods—particularly of *Calanus*—suggested that microorganisms might play a significant rôle (*loc. cit.*). Further investigation of this point showed that bacteria could be ruled out as a possible food source, but left the question open in regard to other types of nannoplankton (Fuller and Clarke, 1936). Since the growth period of *Calanus* off Woods Hole did not coincide with prominent diatom flowerings, Clarke and Zinn (1937) were forced to conclude either (1) that the small number of diatoms always present as a minimum is sufficient, or (2) that the copepods can build up a reserve during local flowerings sufficient to tide them over the intervening periods or (3) that the numerous nannoplankton organisms are important as a food source.

These possibilities introduce the question of the rate at which food is required by copepods. The nutritional demand of a copepod will undoubtedly differ according to its species, sex, age, etc. Furthermore, if, as seems likely from the reports of observers, copepods are omnivorous, the size and composition of the different types of food organisms must be taken into consideration. Doubt has recently been cast by Lowndes (1935) on the view held

heretofore that the feeding of copepods is mainly automatic. But even should feeding prove highly selective, a determination of the amount of food required is essential.

Experiments were carried out at Woods Hole by Fuller (1937) to test the factors influencing the rate at which *Calanus* can remove cells of the diatom *Nitzschia closterium* from the water. He found that of the three temperatures tested, namely 3°, 8° and 13°C, feeding was most rapid at 8°. There was some evidence of a diurnal feeding rhythm with greater activity at night. The fact that change in diatom concentration had no effect on the rate of filtration, and other of Fuller's observations, favored the view that feeding in *Calanus* consists of automatic filtering. Since only about one-half of the organic nitrogen content of *Nitzschia* was found to be digested by *Calanus*, the maximum rate of filtering observed was not sufficiently high to permit a copepod to obtain enough diatoms during the day to satisfy its nutritive requirements as calculated by Marshall, Nicholls, and Orr (1935) on the basis of oxygen consumption. However, studies on the growth of individuals which were supplied with different concentrations of diatoms suggested that less food is needed than these measurements indicated. In addition, Harvey (1937) has just published reports of further tests on the feeding rate of *Calanus* in which much larger species of diatoms (*Lauderia* and *Diitylium*) were used. According to these experiments the copepods can "filter out" the larger cells at rates 5 to 100 times greater than was the case with *Nitzschia*.

In most of these laboratory tests the concentration of diatoms used was considerably higher than that ordinarily found in nature. Although calculations indicate that during naturally occurring maxima

of the larger diatoms food could be obtained rapidly enough to permit growth, long intervals usually exist between such flowerings. The smaller and more numerous types of phytoplankton may then be significant. Furthermore, we do not know whether nauplii of copepods are able to take in the more bulky species of diatoms which generally make up flowerings, since the sizes of food particles suitable for the smaller stages of copepods have not yet been adequately investigated. At certain older stages copepods are able to exist for several weeks without eating—according to our experience at Woods Hole, but we certainly should not expect spawning to take place or the rapid growth of the young nauplii to be possible without a rich supply of suitable food.

Questions such as those left unanswered by the foregoing investigations must be settled before we can hope to follow the course of events involved in the food-cycle of the sea, and to appreciate the delicate

adjustments underlying production in an oceanic environment. Further work on this problem had best be undertaken either in a relatively isolated body of water or in such a large, homogeneous area that currents are not a serious disturbance. Proper allowance can then be made for the time element in production. Work could advantageously be pursued in semi-enclosed bays or estuaries, and information derived from inland waters would probably be applicable in part, although in all these cases the effect of the bottom must be taken into consideration. Further laboratory experiments on nutrition should be coördinated with these observations at sea in an effort to determine the exact relation of the variable diatom population to the success or failure of the copepod crop.

Presented at the *Symposium on Hydrobiology* held jointly by the American Society of Zoologists and the Limnological Society of America at Indianapolis, Indiana, on Dec. 30, 1937.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

THE PROBLEM OF INTEGRATION

Being a review of *Организм как Целое*. И. И. Шмальгаузен, Издательство Академии Наук СССР, 1938. [The Organism as a Whole in Its Individual and Historic Development, by I. I. Schmalhausen. Publishing House of the Academy of Sciences of U. S. S. R., Moscow. 5 roubles, 50 kop. 144 pp. 1938]

By G. F. Gause, Zoological Institute, University of Moscow.

The problem of organic wholeness has interested theoretical biologists at least since the time of Aristotle, and it also has attracted and still attracts the attention of speculative philosophers. This is indeed a fundamental problem worthy of a close consideration, but this latter came in the past more from theorists than from working laboratory people. The quota contributed in this field by working biologists is relatively small, and such a situation is not very fortunate for the advance of the whole problem. The monograph by Professor Schmalhausen now under review shows how biologists are beginning to win the place that properly belongs to them. He is one of the leading Russian biologists, with wide experience in the fields of comparative anatomy and of *Entwicklungsmechanik*, and in this book he attempts to synthesize many contributions from his laboratory with results that have far-reaching significance. The fact that the book is published in the Russian language and hence is not easily accessible to American biologists makes another justification

for our considering here in some detail those parts of the author's argumentation that seem to be particularly suggestive.

The book consists of the following parts: (1) Introduction; (2) Organism as a whole in the individual development; (3) Embryogenesis: phylogeny of embryonic development; (4) Regression: disintegration of correlative systems in the evolution of animals; (5) Progressive evolution: the origin of adaptations; (6) Progressive evolution continued: mutual adjustment of organs.

In the introduction the author points out the significance of the principle of integration, which was realized by Herbert Spencer. Parenthetically, it is just this principle which has been emphasized by Joseph Needham in his recent writings. It is known, on the whole, that evolutionary progress takes the path of increase in the complexity of organization. The whole performing rather general functions differentiates into the parts possessing different specialized functions. These separate parts get their independent functions and are autonomized. However, the proper activity of each separate part is made possible only by a number of functions of general significance. The more a part is specialized the more it depends upon the other parts that guarantee the proper course of the basic living functions of the whole organism, such as respiration, excretion, etc. In other terms all differentiations and specializations are inevitably connected with the advance

in the mutual arrangement of parts, that is to say, with the advance in the level of integration.

The central point of the subsequent discussion which is elaborated by Professor Schmalhausen in much detail is that natural selection represents the factor that contributes to the advance of the level of integration in the process of organic evolution. He starts by consideration of the fact that the integration which finds its expression in the coördinated development of parts in the animal embryo represents an outcome of a long process of historic development. It is indeed true, as numerous experiments of Spemann and of Holtfreter have shown, that at no stage does an organism represent a mosaic arrangement of parts, organs and characters; throughout development it always reacts as an organized whole. In this connection it is significant that the morphogenetic reactions in this developing whole bear a distinct stamp of teleology. For instance, as Spemann has shown, a decrease in size of the embryonic eye-cup brings a corresponding decrease in size of the *Anlage* of the crystalline lens. In other terms various expediently coördinated reactions provide the proper development of the whole embryo even under disturbances of various kinds. An explanation for this fact may perhaps be found in observations of the following type. It appears that the useful restoration of disturbances only takes place when the whole assembly of *somewhat* disturbed parts is normal, that is to say, has behind it a long previous history. If one experimentally brings the developing eye into contact with the ear-capsule, a relation which had never previously occurred in the normal development, the morphogenetic reaction will be distinctly devoid of usefulness and the eye will form an additional retina at the place of contact, as Dragomirow has recently shown in Schmalhausen's laboratory.

The discussion so far outlined deals with the first aspect of the problem of integration: it treats the integrated behavior of individual development and of individual responses to environmental effects. In his attempts to explain this integration by the principle of natural

selection of appropriate reaction mechanisms, Professor Schmalhausen comes to some generalizations concerning the phyletic accumulation of what he calls reaction mechanisms of general significance. A useful response upon the modifying effect of environment, which implies a number of coördinated physiological processes, has at its bottom a specific reaction mechanism which has been gained in the process of natural selection at some time in the past and has not since been lost. As Schmalhausen himself says:

The useful reorganization in the structure of a bone with the change in the character of load, the strengthening of a muscle with the increased work, or the increase of a nervous centre with the expansion in the region of innervation must be evaluated as adaptive modifications of the most general character. The reaction mechanisms of this kind, having once been acquired, do not disappear subsequently insofar as they do not lose their importance (certainly with the exception of some special cases of acquiring sedentary or parasitic habits of life).

The reaction mechanisms of general significance are apparently relatively complicated and do not appear often in evolution, but they fundamentally enter the mechanism of individual development of whole phyla and perhaps of even greater branches in the kingdom of living creatures. Such is, for instance, the significance of adaptive modifications of muscles with differences in their work, the mechanism of which was probably acquired at the very beginning of evolution of the muscular system of vertebrates, or perhaps even earlier.

The adaptive modifications represent only one aspect of the integrated behavior of the individual, and the whole originality of Professor Schmalhausen's book lies perhaps in the rôle that he ascribes to these modifications in the process of further evolution. He believes them to be of importance in determining the path of evolution and particularly responsible for the integrity of its product. But to picture this process as naïvely as the followers of Lamarck have done is certainly no longer possible today because it is proved by genetic science that the acquired characters are not transmitted to offspring, and Schmalhausen is perfectly aware of this fact. Let us consider his attempt to grasp the whole situation from the viewpoint of the principle of natural selection.

It is best to start from the fact that there exists a proved parallelism of non-hereditary and of hereditary responses in

the geographic variation of plants and animals. In many animals a decrease of temperature during individual development causes a non-hereditary increase in size, and an analogous hereditary increase in size is usually recorded in comparing the northern varieties of the same animal with the southern ones. Numerous examples could be cited which conform to this rule. An adequate way for its explanation may perhaps be found in the well-known observations of Goldschmidt, who recorded a parallelism in somatic expression between hereditary mutations and non-hereditary modifications induced in *Drosophila* by high temperature, which he calls *phenocopies*. It is on the whole probable that an organism reacts to the change of environment first by non-hereditary adaptive modifications, the very possibility of which is caused by previous selection of appropriate reaction mechanisms. However, these modifications become soon substituted in population by their hereditary analogues. Schmalhausen reverses here the terminology of Goldschmidt and calls these analogues *genocopies*. The reasons for such substitutions are the following. If a non-hereditary modification is adaptive, i.e., favorable for survival, an hereditary mutation with analogous somatic effect

will be at least not thrown out of the population. But there are reasons to believe that the appearing mutations could in some respect be even more advantageous than the modifications which they duplicate, as far as the somatic effect and the ultimate survival are concerned. For instance, the adaptation required could by means of mutations be made perhaps more radical. Every slight advantage of mutations over modifications in selection will be sufficient to cause the substitution in population of the latter by the former.

The conception of evolution arrived at in the course of this reasoning is extremely interesting, and it appears as if adaptive non-hereditary modifications are preparing the way for the subsequent course of evolution. There are certainly many implications in this conception, but it seems to the reviewer that they need to be made clear by further experimental work that is still lacking.

In concluding it is to be pointed out that the book under review is by no means an exhaustive treatise on the principles of organic integration. Rather it is an attempt to approach some selected aspects of these principles by a biologist with Darwinian philosophy. There can be no question that this attempt is stimulating for further research.

BRIEF NOTICES

EVOLUTION

EVOLUTION. *Essays on Aspects of Evolutionary Biology Presented to Professor E. S. Goodrich on His Seventieth Birthday.*

Edited by G. R. de Beer. Oxford University Press, New York; Clarendon Press, Oxford. \$5.00. 8½ x 5½; viii + 350; 1938.

This commemorative volume bears witness to the esteem in which one of the leading biologists of the British Isles is held by his contemporaries. The caliber of the nineteen essays by as many contributors speaks as loudly of this esteem as the three page bibliography speaks of Dr. Goodrich's own contribution to modern evolutionary biology.

No one today questions that evolution takes place. There is some disagreement

as to how it may take place, but the greatest disagreement will be found as to when it takes place. Just how different from the type a variation must become in order to be considered a new species is a question to which no satisfactory answer can be given. Yet two of the contributors, J. B. S. Haldane and O. W. Richards, have undertaken to give it a partial answer, and have succeeded in throwing light on it, and it is also touched upon by G. R. de Beer, who has also written the preface to the volume.

W. A. Tucker discusses the evolution of the birds. The older theory was that the avian ancestor was an arboreal reptile—that the wings were used for climbing before flying. A later theory made the ancestor cursorial rather than arboreal—

with wings used originally for running. Among birds now extant we find wings used in all three ways—the hoatzin uses its wings for climbing, while the penguin runs on all fours with a trotting motion, the wings striking coordinately with the feet on the opposite side. Mr. Tucker is inclined to agree with the older view. Now the penguin is a rather highly specialized bird, while it is generally believed that the hoatzin is the sole survivor of a primitive type, so that these two birds give much aid and comfort to Mr. Tucker's theory. It is therefore surprising that he makes no mention of them in developing it.

The origin of the crustacea from the trilobites is ably discussed by Walter Garstang, and in other essays the bony fishes, the echinoderms, and the parasitic worms come in for discussion. There is a complete index, but only three illustrations.



MORE DIFFICULTIES OF THE EVOLUTION THEORY and a reply to "Evolution and Its Modern Critics."

By Douglas Dewar. Thynne and Co., London. 8s. 6d. $8\frac{1}{2} \times 5\frac{1}{2}$; [12] + 206 + [9]; 1938.

In this sequel to his *Difficulties of the Evolution Theory*, Dewar makes a reply to A. Morley Davies who, in a recently published book entitled *Evolution and its Modern Critics*, has tried to meet the difficulties set forth by Dewar in the earlier work. So the bickering and passing the buck have extended through three successively published volumes, and inasmuch as concrete proofs are forthcoming from neither side, it is entirely probable that the squabble will continue through an indefinite number of future publications. "He (Davies) asserts positively that in the past an amphibian became gradually transformed into a reptile and calls upon me to prove that this did not happen. I submit that the burden of the proof lies with him who asserts". Here Davies cannot prove a point and Dewar cannot disprove it, so they wrangle on indefinitely.

Dewar presents, as in his previous publications, much rational evidence against evolution by natural selection, but, as usual, fails to give the slightest evidence in favor of special creation. The most interesting part of the book is a chapter entitled "Difficulties presented by some instincts", in which the author describes the process of nest-building of the Indian tailor bird, the oriole and the weaver bird—a topic on which his wide field experience as an ornithologist has well qualified him to write.

The volume contains an index, a glossary and a few charts and drawings.



THROUGH THE GREAT ARID FILTER (Man's Drift to Europe).

By A. J. McNerny. Obtainable from the author, A. J. McNerny, % Printerdom, Otley, Yorks, England. 2s. $8\frac{3}{8} \times 5\frac{1}{2}$; 46; 1938 (paper).

This interesting book stresses the importance of deserts in the evolution of man, and particularly of the white race. It is a difficult book because badly organized and badly written. The central thesis is indicated in the following passage, perhaps as well as in any that could be chosen:

Thermal Aridity is the *Alma Mater* under whose care the intellectual development of man has been fostered. It was during the times of the slowly disappearing Wurm Ices that the lowly ancestor of man, who had been struggling during the whole Pleistocene period to fit himself for it, was to receive the first earnest of a new intellectual regime destined to attain fruition, in the West at least, around the Caspian shores and in North Africa. In decrying the deserts, it is useless to lose sight of the necessary elements which we find only in those sun-scorched regions. A place has to be provided, in the economy of our existence, for these indispensable cleansers of our atmosphere.



ELIMINATION UND SELEKTION. Eine Untersuchung über Merkmalsprogressionen bei Tieren und Pflanzen auf genetisch- und historisch-chorologischer Grundlage.

By W. F. Reinig. Gustav Fischer, Jena. RM. 8. $10 \times 6\frac{1}{2}$; viii + 146; 1938 (paper).

Reinig attempts to arrive at a uniform conclusion for the northern hemisphere, as to the origin and distribution of plant and animal species due to changes in geological periods. He especially stresses the glacial and post-glacial changes as resulting in migrations. There is considerable amount of speculation as to the part played by these factors in the process of elimination and selection.

A number of maps and tables are inserted to illustrate the author's points, and the volume is indexed.



GENETICS

STRUCTURAL VARIATIONS OF THE HUMAN IRIS AND THEIR HEREDITY *with Special Reference to the Frontal Boundary Layer.*

By Viggo Eskelund. *Nyt Nordisk Forlag, Arnold Busck, Copenhagen; H. K. Lewis and Co., London.* 218. net. 10 x 7½; 242 + [1]; 1938 (paper).

Although such notorious families as the Jukes and Kallikaks have shown a rather wanton broadmindedness concerning illegitimate progeny, society, in general, adopts a far more censorious attitude toward *filiis nulli*. Since blood-type tests serve only to exclude possible fathers, extensive anthropological and hereditobiological examinations have been tried for a more desirable result; that is, proof of the actual identity of the father. "von Vershuier now considers himself able to exclude paternity with certainty in 14 per cent of cases, with great probability in a further 14 per cent and can indicate the probable paternity in 56 per cent, while it is only in the remaining 16 per cent that he cannot decide either for or against possible paternity."

In connection with the studies on paternity, there has been much research on the inheritance of the pigmentation of the iris, but the structure of the iris and its inheritance have, with the exception of a few papers by Josef Weninger, been little investigated. Eskelund presents his extensive study on the structure of the human iris, its frontal aspect, and its structural variations and their heredity. In addition to the chapter dealing with

photographic technique, schemes of classifications of the variations of the iris, frequency and mutual relations of the variations, relations between structure and pigmentation of the iris, width of the cornea, the inheritance of structural variations of the iris and of variations of the cornea are discussed. The author's study on inheritance was based on 15 married couples, their 44 children, and 14 children of whom only one parent was examined. Included in this investigation are the results of the author's researches on iris and corneal variations in 5 sets of twins, three of which were supposedly uniovular and two binovular.

There are many full page photographs of the human eye, each accompanied by a formula giving the exact structure of the iris of the particular case. Also available in this book are the detailed reports of the cases studied.



GENETICS. *An Introduction to the Study of Heredity. Fourth edition.*

By Herbert E. Walter. *The Macmillan Co., New York.* \$3.00. 8½ x 5½; xvii + 412; 1938.

The advance that has been made in genetic science since the appearance of the third edition of this work eight years ago has made the preparation of a new text imperative. The present work, however, cannot be called a revision—in fact, the author himself tells us that it is a new book under an old title. The student who has become used to the predecessors of this volume is likely to find nothing familiar to him except the name and the delightful sense of humor that continually crops out in unexpected places; but he is likely to regret the omission of the reference to the pied piper in the discussion of Weismann's family of 1592 rats.

The most conspicuous departure in the present text is the inclusion of numerous portraits of the founders of and contributors to the science of genetics from Koelreuter in the 18th century to the present day, which contribute to its human interest. Less obvious but more important differences are the inclusion of a lucid and well written chapter on the

fundamentals of the biometrical method and a detailed description of chromosome maps of *Drosophila* from T. H. Morgan. Unfortunately the inclusion of so much new material has forced the exclusion of much that was in the earlier editions and a situation is precipitated that reminds the reader of the snapping turtle, which, in order to withdraw its forequarters into its shell is compelled first to extrude its hindquarters. The student who acquires this book is advised not to dispense with his old copy. The bibliography covers 6 pages and the index 10.



THE CHEMISTRY OF THE INDIVIDUAL. *Being the Thirty-eighth Robert Boyle Lecture Delivered before the Oxford University Junior Scientific Club on June 12, 1936.*

By J. B. S. Haldane. Oxford University Press, New York. 40 cents. $8\frac{1}{2} \times 5\frac{1}{2}$; 17; 1938 (paper).

This scholarly work by Professor Haldane brings to light a case which has been proved for dwarf mice, where there is a recessive gene affecting production of anterior pituitary hormones. Such animals are sterile and do not live long under ordinary conditions. In the case of Sebright fowls, there is no gene affecting the rate of production of hormones, but one which affects the threshold of the epidermis to hormones. In general, the author has given much convincing evidence that genes operate all along the line of development, and can affect a certain result in various ways.

"It is better," in the words of the author, "to adopt a more physiological point of view and say that such and such a normal gene determines not a unit character, but a unit process, or a unit chemical reaction; that is to say, one of those which leads up to the development of a given character." Emphasis is placed upon the fact that genetics is now a "physiological" study, and links into many fields, including endocrinology, biochemistry, embryology, immunology, and cellular physiology.

THE STUDY OF HEREDITY.

By E. B. Ford. Thornton Butterworth, London. 2s. 6d. net. $6\frac{1}{2} \times 4\frac{1}{2}$; 256; 1938.

The principles of genetics are clearly and competently discussed in this booklet written especially for the layman. The subject matter is presented in the usual form. There is first of all a brief description of the chromosomal mechanism and of Mendel's theory followed by chapters on the heredity of sex, variation, evolution and on some inherited characteristics observed in man. The illustrative examples from observational and experimental data have been very well chosen but the author has apparently been unable to avoid the use of a technical terminology. On the whole, the book deserves praise as a condensation of the subject to aid the undergraduate student in biological sciences rather than as a successful effort at popularization. In this respect, the value of the book would have been increased considerably by the use of pictures and drawings. There is a glossary, an index and a very sketchy bibliography.



THE MEASUREMENT OF LINKAGE IN HEREDITY.

By K. Mather. Chemical Publishing Co. of New York, New York. \$1.75. $6\frac{1}{2} \times 4$; ix + 132; 1938.

This is an excellent small book for the geneticist. However, even with the introductory chapter which explains briefly the methods involved, a non-mathematical reader would be unable to get the full benefit of the discussion. Chapters are devoted to the ways of estimating the number of individuals necessary in planning an experiment, in detection and estimation of linkage, and in testing for heterogeneity. The χ^2 test of significance and the method of maximum likelihood are stressed in treating the above problems, although other statistical methods are suggested. The author uses these same techniques in dealing with disturbed segregations involving coupling and repulsion. Human hereditary analyses are complicated by the small size of families and lack of information concerning the

genetical constitution of the matings. Brief treatments of these limitations are presented for human single factor segregations and linkage.

Throughout the pages numerous examples demonstrate the points in question. The final chapter consists of formulae, symbols, and short tables to facilitate calculations.



GENERAL BIOLOGY

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION *Showing the Operations, Expenditures, and Condition of the Institution for the Year Ending June 30, 1937.*

Smithsonian Institution. U. S. Government Printing Office, Washington. \$1.00. 9½ x 5½; xv + 580; 1938 (paper).

For the benefit of those, who, with a general interest in science, are unacquainted with these annual reports, we strongly recommend the expenditure of one dollar for this volume which is heavy and unwieldy to handle and gives (in its external appearance) every indication of being dull. The first part is mostly dull, dealing, as reports do, with finances, numbers of visitors to the different departments (U. S. National Museum, Freer Gallery of Art, National Zoological Park, etc.), lists of staff members, donors of gifts, etc. However, even here we find much that is interesting concerning Mr. Mellon's fine gift to the nation, recent acquisitions of the Freer Art Gallery—and some will even enjoy glancing through the list of animals in the National Zoo.

On page 127 begins the general appendix. Under the heading "Advertisement" we read the following:

It has been a prominent object of the Board of Regents of the Smithsonian Institution from a very early date to enrich the annual report required of them by law with memoirs illustrating the more remarkable and important developments in physical and biological discovery, as well as showing the general character of the operations of the Institution; and, during the greater part of its history, this purpose has been carried out largely by the publication of such papers as would possess an interest to all attracted by scientific progress.

It is this particular section of the report that we wish to call attention to. Unfortunately, it is impossible to mention all of the interesting papers which Dr. Abbott, the Smithsonian Secretary, has herein assembled (a total of 28); only a few of biological interest can be listed. J. H. Kempton contributes a paper on Maize—our heritage from the Indian (30 plates); Leonard P. Schultz writes of the breeding habits of the salmon and trout (5 plates); George S. Meyers on Fresh-water fishes and West Indian zoogeography (3 plates); Walter C. Alvarez on The emergence of modern medicine from ancient folkways (1 plate); William Robinson on The healing properties of allantoin and urea discovered through the use of maggots in human wounds; Wilmot A. Bradley on The biography of an ancient American lake (4 plates). All of the articles are well written and are comprehensible to the layman. The photographic plates are well chosen and beautifully executed. We think that all general libraries, and particularly high school libraries, should give these annual reports a prominent place on their shelves.



A LABORATORY AND FIELD GUIDE TO BIOLOGY.

By Samuel H. Williams. The Macmillan Co., New York. \$1.25. 6 x 4½; xxv + 130; 1938.

A MANUAL FOR THE BIOLOGY LABORATORY.

By Perry D. Strausbaugh and Bernal R. Weimer. John Wiley and Sons, New York; Chapman and Hall, London. \$1.75. 11 x 9; ix + 183; 1938 (paper).

Professor Williams feels that present methods of teaching biology are all right insofar as the student is preparing for medicine or biological research, but that those who select biology as a cultural subject will find more interest in the study of living organisms in their natural habitats. Consequently this book was prepared to provide a working method for biology study in the field. It consists of a series of exercises which include directions for the student to follow. The exercises are concerned with the various

groups of animals and plants commonly found in most areas.

The *Manual*, besides giving the usual instructions for laboratory dissection and observation, also includes space where the student may draw what he sees. Some of the drawings have already been started for him so that all that is required is the addition of a few lines to complete them.



LA VIE DANS LA RÉGION DÉSERTIQUE
NORD-TROPICALE DE L'ANCIEN MONDE.
Société de Biogéographie VI.

By L. Aufrère, F.-S. Bodenheimer, A. Chevalier, L. Chopard, L. Emberger, H. Foley, H. Gauthier, L. Joleaud, Ch. Kilian and D. Féber, R. Maire, Th. Monod, P. de Peyerimhoff, A. Reymond, L.-G. Seurat, P. Teilhard de Chardin, B.-P. Uvarov, B. Zolotarevski and M. Murat. Paul Lechevalier, Paris. 175 francs. 10 x 6½; 406; 1938 (paper).

This volume presents twenty separate papers by eighteen different authors on all phases of life in the desert regions of the old world. Four of the papers describe the formation and extent of the deserts of Asia and Africa. The others deal with general biology, soil biology, flora, fauna, and human pathology of the desert regions. Fundamental findings seem to indicate that the desert flora is, in large part, made up of the survivals of the old xerophytes of the tertiary. The fauna of the desert differs in general from that of regions of more temperate climate and normal rainfall in being especially adapted to resist excess heat and evaporation, and in having a life cycle adapted to the radically different yearly cycle of environmental conditions.

A summary chapter by H. Monod is included, giving a simple résumé of the separate papers.



RATIONALE BIOLOGIE UND IHRE KRITIK.
(Eine Auseinandersetzung mit dem Vitalismus
H. Driesch's).

By Eugen Heuss. Verlag von S. Hirzel, Leipzig. RM. 6. 9½ x 6½; ix + 192; 1938 (paper).

This is a rather difficult philosophical treatise on the fundamentals of theoretical biology. Unfortunately, the style of writing lacks clarity, thereby adding to the difficulties of understanding the author's ideas. It deals especially with Driesch's theory of vitalism and his doctrine of entelechy by which he means a specific biological agent which is alleged to form the world of organism *a priori* and independent of other experience. Therefore biological knowledge is a knowledge *sui generis* and cannot be explained only as a kind of life mechanics. There is an appendix on Kant's discussion of vitalism.



A SELECTED BIBLIOGRAPHY ON MANAGE-
MENT OF WESTERN RANGES, LIVESTOCK-
AND WILD LIFE. U. S. Department of
Agriculture. Miscellaneous Publication No.
281.

By F. G. Renner with the assistance of
Edward C. Crafts, Theo C. Hartman and
Lincoln Ellison. Government Printing
Office, Washington. 45 cents. 9½ x 6;
ii + 468; 1938 (paper).

This bibliography includes the more important references to publications relating to western grazing lands of the United States—the domestic livestock, wild life and plants—comprising seventeen states and Alaska, with the exclusion of eastern Texas and eastern Oklahoma. It is believed to be complete through 1933 and some of the more important references from 1934 to 1937 have also been included. The sectional headings are distinctly defined as to the scope of the material and cross references are listed at the end of each section. An author index is appended. A very valuable contribution.



DEUTSCHES BIOLOGEN-HANDBUCH. Eine
Übersicht über die deutschen Biologen, die
biologischen Institute und Organisationen.
2. Auflage.

Edited by Ernst Lehmann and Otto Martin.
J. F. Lehmanns Verlag, München and
Berlin. RM. 8; for members of the
Deutscher Biologen-Verband, RM. 7.
8½ x 5½; viii + 261; 1938.

In addition to bringing this book (first edition noticed in Q. R. B. Vol. 10, No. 4) up-to-date with reference to changes in personnel the editor has expanded it to include all biologists working in institutions, schools, publishing houses and newspaper offices, museums, etc. in Germany; also a list of biological societies in that country. Former Austria is included. A few German societies and investigators in other countries are likewise mentioned.



BIBLIOGRAPHIA BIOTHEORETICA *quam ediderunt qui praesunt Foundationi cui nomen est "Prof. Dr. Jan van der Hoeven-Stichting voor theoretische biologie van dier en mensch, verbonden aan de Rijksuniversiteit te Leiden"*. Serie C. Titulos Librorum, etc. Annorum MCMXXV, MCMXXVI, MCMXXVII, MCMXXVIII, MCMXXIX, collected and edited by J. H. Diemer and C. J. van der Klaauw.

Edited by C. J. van der Klaauw, J. A. J. Barge and Ad. Meyer. E. J. Brill, Leiden. 11 guilders. 9½ x 6½; xi + 236; 1938.

A list of 4802 titles in the field of theoretical biology published during the years 1925-29. The bibliography (divided into 21 categories) is intended for all workers interested in the theoretical side of their branch of science; namely, in the notions, conceptions, mathematics, and general theories in the field of biology or medicine. It is planned to begin the publication of annual bibliographies of this kind from 1935 on.



A LABORATORY MANUAL OF GENERAL BIOLOGY. *Second Edition.*

By E. Grace White. C. V. Mosby Co., St. Louis, Mo. \$1.75. 10½ x 7½; 262; 1938 (paper).

The present laboratory guide (cf. Q. R. B., Vol. 8, No. 4 for review of first edition) follows the changes and additions in the second edition of the author's *Textbook of General Biology*. Among these changes should be especially mentioned the addition of the material on the dogfish, and the section on field study.

SIR JOSEPH BANKS ISLANDS. *Part I. Reports of the McCoy Society for Field Investigation and Research.* No. 2.

McCoy Society. Reprinted from the *Proceedings of the Royal Society of Victoria*, Vol. 50, Pt. II. 9½ x 6½; 303-413; 1938 (paper).

A list of plants and animals and their distribution found in a group of about 20 islands, islets and reefs lying eastward of Louth Bay in Spencer Gulf, South Australia.



THE UNIVERSITY OF COLORADO STUDIES, Volume 25, Number 2. *Papers concerning Junius Henderson, Curator of the University of Colorado Museum from 1900 to 1933.*

University of Colorado, Boulder, Colorado. \$1.00. 10 x 6½; 117-160; 1938 (paper).



HUMAN BIOLOGY

KNOWLEDGE AND SOCIETY. *A Philosophical Approach to Modern Civilization.*

By G. P. Adams, W. R. Dennes, J. Loewenberg, D. S. Mackay, P. Marhenke, S. C. Pepper and E. W. Strong. D. Appleton-Century Co., New York and London. \$2.75. 8½ x 6; xiii + 417; 1938.

Some time ago a critic whose intellect was more brilliant than profound compared the metaphysician to a blind man in a dark room trying to catch a black cat that wasn't there. If this idea of what constitutes metaphysics is more prevalent than it should be the metaphysicians themselves are largely responsible, for the esoteric nature of much metaphysical literature is due in no small degree to the philosophical jargon in which it is couched.

The collaborating authors of the work under consideration have avoided this pitfall. In some places their drift is hard to catch, but this is generally due to the profundity of the thought rather than to its concealment under an efflorescence of verbiage. The result is that this work misses being a really great book by the narrowest of margins.

It is not likely that anyone will accept

all the conclusions, or even all premises from which the authors start. Consider, for instance, the conception of the nature of law promulgated by the authors, upon which their answer to the question as to freedom of the will is largely based. Law, they tell us, is a term used to designate two fundamentally different things. Natural law has no more in common with human law than the stock that grows in our gardens has with the stock that is traded on the floor of the bourse. Natural law is descriptive, human law is prescriptive. The one tells how objects behave, the other how persons ought to behave. The one cannot be broken, the other may be.

Over a generation ago this conception of law was shown by Pearson in *The Grammar of Science* to be altogether erroneous. A law in any case is a descriptive formula. The Natural Law of gravitation does not tell us objects fall; it tells us how objects ought to fall if their behavior is to be consistent with that of similar objects which have been observed to fall in the past. Similarly with human law. The first human laws were taboos. First a custom was established, then laws were formulated to define the custom and forbid deviation from it. For this reason primitive legal codes such as the decalog are largely prohibitory.

Does this interpretation of law invalidate the conclusions of the authors as to freedom of the will? By no means. Kepler's laws of motion are formulated, although the premises on which they are based contained two serious errors—which neutralized each other. Most philosophers accept the doctrine of freedom on pragmatic evidence—the will feels free. Pragmatic evidence is not always the best kind, but in this instance no other evidence is available—there can be no empirical method of demonstrating freedom of the will. If having made a choice we could then turn backward the wheel of time in its flight to the instant when the choice was made, and then make a different choice, freedom would be demonstrated, but because the wheel of time cannot be so turned back the making of a choice precludes the possibility of demonstrating that an alternative choice was

possible. When an individual makes different choices under circumstances that appear to be the same it may well be that some unnoticed factor that differed in the two instances conditioned the choices. Therefore the question "Is the will free?" is hardly a legitimate one, for it postulates the availability of evidence that we believe to be non-existent. It would have led to more satisfactory philosophical results had freedom been accepted as a postulate in which case the arguments pro and con concerning mechanism, vitalism, mysticism, rationalism, and theism might have been made more convincing.

The book is divided into two parts—the first dealing with absolute and the second with applied philosophy. The opening chapters deal with common sense and the scientific method, and are well thought out and well expressed.

In these days when all philosophies of economics, politics, and sociology are subject to change without notice the value of such a work as this is inestimable to those who find it difficult to think through to a conclusion the conditions that confront us. To such persons no recommendation of this work can be too high.



AUDUBON THE NATURALIST. *A History of his Life and Time. Second Edition.*

By Francis Hobart Herrick. D. Appleton-Century Co., New York. \$6.00. 8½ x 6; vii + 500; 1938.

The present year saw the centennial anniversary of the publication of Audubon's "Birds of America," and it is therefore appropriate that a new edition of the classical biography of this early figure in American ornithology and mammalogy should appear. The first edition of this work appeared twenty years ago and so carefully had it been compiled that no serious alterations in the text have been involved, but it has been necessary to expand the introductory portions owing to the recent discovery by the author of some documentary evidence bearing directly on the mystery of Audubon's birth, a matter about which Audubon himself told many conflicting stories. Dr. Herrick believes that this was done to conceal

the illegitimacy of his birth, and it must be confessed that the physician's bill, the certificate of baptism, the power of attorney given by Audubon to his brother-in-law in later years, and the efforts of relatives to break his parents' wills, taken together seem rather convincing.

The rumor of the identity of Audubon with the dauphin who was to have been Louis XVII which has become current in recent years seems to rest on no evidence except that they were of substantially the same age, and that Louis made his exit from history at about the same time Audubon entered it. It may be dismissed at once, for the researches of Watson Dewees indicate that Stephen Grellet positively identified Eleazer Williams as the dauphin in the presence of John Collins. But, as Dr. Herrick has remarked, Audubon's life was so romantic that it needs no bolstering up by any rumor connecting him with royalty. Born in Hispaniola; studying painting under David in Paris and Sully in Philadelphia; making his home successively in Pennsylvania, Ohio, Kentucky, Louisiana, New Jersey, and New York; becoming by turns a miner, a merchant, and a miller, and failing at all three occupations; collecting natural history specimens throughout the United States as then constituted, and the independent republic of Texas as well; supporting himself as he went by giving lessons in drawing, painting, dancing, and playing the flute and violin, while his wife kept the home fires burning and brought up the children; finally achieving recognition in England whither he had gone to take orders for the *Birds of America*; enumerating among his friends Thomas Say, Lucien Bonaparte, Titian Peale, Daniel Boone, Reuben Haines, Richard Harlan, Thomas Nuttall, and John Townsend, and among his acquaintances if not his friends George Ord, Isaac Lea, and Gerard Troost—his life was even more interesting, as he himself wrote, than that of his father.

Yet to the present reviewer there are two figures in the background whose lives seem more appealing in their individualities than that of the propositus, and Herrick is to be thanked for the wealth of biographical material which

he has accumulated about them. They are Alexander Wilson, who was painting birds within a few miles of Audubon in Philadelphia, although neither of them knew it until they met by accident in Louisville, Kentucky many years later; and that erratic and incomprehensible talent Rafinesque, who so narrowly escaped being a genius, and whose hybrid ancestry surpassed even that of Lafcadio Hearn.

Herrick places the responsibility for keeping Audubon out of the Academy of Natural Sciences squarely upon George Ord. But he makes no mention of the part played by Gerard Troost, nor does he mention the fact that Audubon was eventually admitted after the death of Troost.

Those who read biographies because they enjoy the lives of picturesque characters of the past will be delighted with this work, for it is fascinating reading. But apart from this it is a work of scientific value, as its 16 pages of chronology, its 18 pages of index, its 61 pages of bibliography, its 87 pages of miscellaneous appendices, and its 116 well executed illustrations all bear witness.



OCKHAM. *Studies and Selections.*

By Stephen C. Tornay. Open Court Publishing Co., LaSalle, Ill. \$1.75.
7 $\frac{1}{2}$ x 5 $\frac{3}{8}$; viii + 207; 1938.

The author of this work has attempted to compress an immense quantity of material into a lamentably small space and to do so has resorted to extensive documentation. The book would have been more readable if it had been expanded and the documented material represented by incorporations into the text.

An indispensable prerequisite to an understanding of Ockham's philosophy is a thorough familiarity with the vocabulary of mediaeval metaphysics, and unfortunately but few readers are so prepared. Many will feel, on essaying this book, that like Polonius they are reading "words, words, words." What, for instance, can the average reader make of such a statement as this: "Logic, which used to teach *vere loqui* began after its alliance with grammar to teach *recte*

loqui."? Are we to understand by the terms logic and grammar what passes under these names today, or are we to accord them the meaning they had in the classical *Trivium*?

This is a difficult point to decide. The three subjects in the *Trivium* were logic, grammar, and rhetoric, which designated respectively the art of thinking, the art of self expression in writing, and the art of self expression in speaking. The mastery of these three subjects would be considered a liberal education even today. But Ockham lived in a critical period. Education was in a state of flux. Established methods of expression were undergoing deep seated changes as the result of the breaking up of classical Latin into the Romance languages, and even philosophical Latin, though a dead language, was still undergoing the deterioration so much lamented by Boethius (and which continued long after Ockham's day—compare the Latin of Linnaeus with that of Thomas Aquinas or Cicero). The exactitude of expression of classical Latin began to disappear at the time of the barbarian invasions. Partly because Ockham insisted on exactitude in his definitions of terms the author regards him as the founder of modern scientific method, and intimates that without him there might have been no Leonardo da Vinci, no Roger Bacon, no Copernicus, Descartes, Galileo, or Newton.

And yet, Ockham was strangely inconsistent. As a nominalist he shared with Democritus and Lucretius and the other atomists a belief in the immutability of types, but he also believed in a formless primordial substance, from which all secondary substances were derived by the assumption of form by its ultimate particles—a belief which suggests not only the modern electronic theory, but also that of the alchemists concerning the transmutation of the base metals into gold.

There is very little of a biographical nature set out in this book—for very little is known of the life of Ockham. The date of his birth is uncertain, but it occurred early in the 14th century. It is known that he joined the Franciscan order and so brought down upon his head the wrath of Pope John XXII for which he

suffered incarceration at Avignon. After four years he escaped and then established himself at Munich under the protection of Louis the Bavarian. Here he turned his talents from philosophy to sociology and politics, and with his pen attacked the degeneracy of the papacy, the abridgment of free speech, the use of violence even in a good cause, and capital punishment. He died in 1349 a victim of the Black Death.

It is difficult to appraise the character of such a man. He is revealed to us chiefly through his pen, and perhaps the more important part of this book is the second half, which consists of selections from his philosophical writings. The author considers Ockham to be greater as a philosopher than as a social reformer, and therefore ignores his sociological output. Yet the reader is likely to be left with an insatiable curiosity to know something about his political and sociological writings, and to regret that selections from them were not included. All of which brings us back to the first statement in this review—that the covers of this book are too close together to do justice to the remarkable character whom it celebrates.



BIOLOGY AND MARXISM.

By Marcel Prenant. *International Publishers, New York.* \$2.50. 8½ x 5½; xxiii + 223; 1938.

There is a school of thought which places Marxism in the category of religions and this view seems to be well grounded when it is noted how strong is the faith that the Marxists manifest towards the written words of the master and his principal apostles: Engels and Lenin. Such a faith pervades this work in which Prenant discusses the validity of dialectical materialism as the philosophical method of approach to the study of biology, and of human evolution in particular. The main thesis advanced by the author is that the "Marxist philosophy of dialectical materialism, being a sort of quintessence of the scientific method itself, is able to help the biologist both by pointing the way towards the kind of hypotheses

which it will be most profitable for him to form and by indicating which questions are meaningless and which are unanswerable." To prove his thesis the author first of all presents an excellent outline of the existing knowledge in biology. He discusses in a thorough and sound manner the cell, heredity, evolution, animal behavior and societies, population growth and kindred topics. He then proceeds to show how the modern discoveries and conclusions would have been quickly achieved if investigators had been guided by the writings of Marx, Engels, or even Lenin. Typical is his treatment of the problems of population growth. After citing the studies of Pearl, Gause, and Teissier he notes that Engels was already aware of the existence of "laws" of population growth because he had said: 'For that matter, the organisms of nature also have their laws of population, which have been left almost entirely uninvestigated, although their formulation would be of decisive importance for the theory of the evolution of species'. Prenant omits to say that many others, even though not followers of Marx, had already expressed the same or similar thought. In a way, the efforts of Prenant remind one of the literary game in which references to automobiles and other modern inventions are sought in the plays of Shakespeare. But the author is grimly serious, and his conclusion in essence is that the modern developments in biology have demonstrated the correctness of Marx's views, and that therefore the future will also show that the classless society visualized by Marx is the end result of the evolution of man. There is a very laudatory foreword by Joseph Needham who, however, seems to have arrived at an interpretation of dialectical materialism different from that of Prenant, thus increasing the reader's confusion.



THE LIFE OF CHEVALIER JACKSON. *An Autobiography.*

By *Chevalier Jackson. The Macmillan Company, New York.* \$3.50. 8½ x 5½; x + 229 + 64 plates; 1938.

The story of his childhood and early

adolescence is here given in far more interesting detail than are the well-known scientific adventures of this famous doctor. However, his early struggles against poverty, a frail physique and great sensitivity, climaxed by serious illness in later life, only help us to appreciate the magnitude of his achievements. He writes at length of the agony of his days at school where he bore in stoical silence the teasing and physical brutality of his larger classmates, but of his years in Jefferson Medical College he speaks only briefly, preferring to enlarge on his hardships and starvation diet during that time rather than upon his professors and their teachings.

Influenced by the writings of Sir Morell Mackenzie to study laryngology, he sailed (steerage) to England to visit the Mackenzie clinic, giving a full account of his crossing and poor rations while in London, but neglecting to mention again either Mackenzie or his clinic. At the early age of 35 Dr. Jackson was elected to the chair of laryngology at Western Pennsylvania Medical College and later professorships were created for him in many leading universities, but throughout the rest of the book as in the earlier part the account of his professional activities is not given in as much detail as those interested in the work rather than the character of the man might wish. He prefers to emphasize his abhorrence for tobacco and alcohol, the amazing extent of his charity work, and his idealistic aims in training assistants and spreading his knowledge.

The volume is lavishly illustrated with sketches by the author who is artistically as well as scientifically inclined. An index and a group of photographs both personal and professional supplement the text.



THE NEXT BRITISH EMPIRE. *A Population Policy for Home Amenities and Empire Defence.*

By *R. A. Piddington. John Murray, London.* 6s. net. 7½ x 5; xi + 294; 1938.

Any sensible person, even though English, can see that the outlook for the future of the British Empire is not very bright. Various not very successful attempts have

been made to stir the powers that be into doing something about saving Great Britain from the decline they believe is imminent. This book has just such a purpose. The author sees the signs of an early collapse in the falling English birth-rate which is the effect, he notes, of urbanism and excessive population density in general. After depicting in very dark colors how Great Britain will become the prey of other and more virile countries if the present trend is allowed to continue unchecked, the author presents as his remedy a plan of action that is at least drastic and exciting. He proposes to move the people of the British Isles lock, stock, and barrel to Canada and establish there the center of the Empire which would contain only Canada, Australia, New Zealand, South Africa, and the geographic features of what are now the British Isles. He considers giving India back to the Indians; much of Africa to Germany (or anybody who wants it); ditto for Gibraltar, Malta, etc. In this way most of the have-not countries would be appeased, Australia and Canada would be protected, and the British Empire would survive in a more compact form. In addition, by careful planning, the present ills—unemployment, dole and over-industrialization—could be avoided and the Empire would flourish again and everybody would live more happily. The author's earnestness is impressive and the brilliantly written book makes interesting reading. The clear and cogent analysis of the principal factors associated with the declining birth-rate is masterly. Altogether this is a remarkable book, even though its suggested solution does not seem at the moment altogether probable as realistically practicable.



GROUP ADJUSTMENT. *A Study in Experimental Sociology.*

By Wilber I. Newsletter, Marc J. Feldstein and Theodore M. Newcomb. *School of Applied Social Sciences, Western Reserve University, Cleveland, Ohio.* \$2.00. 9 x 5½; xv + 154; 1938.

Experimental sociology is one of the developments resulting from the realization

that notwithstanding all the tomes on sociology our knowledge about social behavior is practically nil. Utilizing various ways and means, scattered small groups of investigators are now attempting to develop and apply observational techniques to the study of group behavior. The Wawokiye Camp research project about which an account is given in this volume represents one of these. In essence, the methods used here have already been employed by child psychologists and consist in observing and measuring the attitude and behavior of adolescents in their contacts with one another. A technique of measuring and scoring the individual behavior has been developed and is described here, but from the account given a judgment on its adequacy cannot be reached. One of the principal conclusions drawn from this investigation is that the group status of the individual is highly correlated with the cordiality manifest by the group towards the individual but is found to have a low correlation with the attitude of the individual towards the group.

It must be noted in passing that the correlation coefficient has been employed here with the same familiarity and non-chalance one usually finds in statistical investigations by students of psychology and education; a fact which always chills the blood of the biostatistician who is only too aware of the pitfalls connected with that valuable statistical constant.

However, this is pioneer work and deserves to be encouraged; moreover any attempt to evaluate either methods or results at this stage would certainly be premature.



CLIMATE AND ACCLIMATIZATION. *Some Notes and Observations.*

By Sir Aldo Castellani. John Bale, Sons and Curnow, Ltd., London. 10s. 7½ x 4½; ix + 198; 1938.

Professor Castellani repeatedly states that this discussion regarding the effects on man of variations in climatic conditions must be regarded simply as a collection of notes. Nevertheless, it turns out to be an adequate summary of the subject particu-

larly valuable because the comments are dictated by the author's long experience and unusual competence. Following an introductory chapter on climatology, the remainder of the book is a critical survey of the facts about the changes in bodily functions and in disease susceptibility produced by changes in temperature, pressure, winds and other atmospheric conditions with special reference to the effects noted on the white man in the tropics. In addition, the writer outlines the measures which he considers most useful to aid the acclimatization of the white man in tropical and sub-tropical regions. For some time Castellani has maintained that the alleged deleterious action of the tropical climate on the white man has been greatly exaggerated, although some effects on the endocrine system and in the psychic sphere are to be noted. The majority of diseases which affect the Europeans in the tropics can be prevented, he believes, and in proof presents the really splendid results he obtained as chief of the Italian Medical Corps during the Ethiopian invasion. Judged by past experience, it would seem almost incredible that among one-half million troops in the field not one death was reported from dysentery and not one case of typhus, beri-beri, cholera, or gas gangrene; and that in total the morbidity and mortality (from disease) of the troops in Ethiopia was less than the experience of the army at home. These results must be a source of satisfaction to the author and are the most striking indications of the great progress that has been achieved in hygiene and sanitation.



AFRICA'S GOD. IX—*South Africa. Anthropological Series of the Boston College Graduate School, Vol. III, No. 2.*

By Joseph J. Williams, S.J. Boston College Press, Chestnut Hill, Mass. \$1.00. 9½ x 6½; 54; 1938 (paper).

In Part IX of his study on the religion of Africa, Williams presents the replies from South Africa's missionaries, government officials, and educated natives to his questionnaires on tribal religions.

Despite the presence of a maze of tribal superstitions involving propitious and ma-

lignant spirits, ill-remembered oral traditions concerning former tribal beliefs and modes of worship, ancestor-cults, and decadent and vestigial religious practices, the collected evidence points to the fact that monotheism is, or has been, practiced in the tribes of South Africa. The question of past Hebraic contacts with South African tribes is interestingly discussed, and the many similarities between Pentateuchal Laws and the tribal customs are noted, especially those of circumcision, the levirate, purification of women after child birth, cleaning rites after burial, and peace-offerings. There are pointed out in the material on the Zulus as many as thirty parallels to Jewish customs, and on the Basutos twenty-five customs suggesting Jewish origin.

Possible etymological origins of the different names by which the Supreme Being is called in the many tribes, interesting historical data about the tribes, especially that concerning Chaka, the former Napoleon of South Africa, and divers other odd bits of information concerning South African tribes by persons well acquainted with all their peculiarities are included in this pamphlet. In addition, there is an article by J. W. Murphy, S. J. on the excavation of ceramic fragments at Teleilat Ghassul in the southern section of the Jordan Valley.



HISTORICAL AND ETHNOGRAPHICAL MATERIAL ON THE JIVARO INDIANS. *Smithsonian Institution, Bureau of American Ethnology, Bulletin 117.*

By M. W. Stirling. U. S. Government Printing Office, Washington, D. C. 35 cents. 9½ x 5½; xi + 148 + 37 plates + 1 folding map; 1938 (paper).

Translations of many historical accounts of the Jivaro Indians (habitat: eastern Ecuador) largely make up the first half of this bulletin. From the sixteenth century these tribes have had contact and conflict with soldiers, missionaries, gold seekers, and commercial fortune hunters. Yet their method of living and the nature of the land has made them indomitable.

The story of the present day Jivaro is one of much interest. Stirling tells of the

warlike manner of the Indians, with detailed accounts of their taxidermic art in preparing heads. Primitive traditions abound in the otherwise simple domestic life of these people, but as in many primitive cultures, some of the customs and superstitions may have a sound physical basis. For one learns that when treating a patient the witch-doctor sucks the afflicted part and spits out the evil spirit. Some illnesses are not due to these disease spirits.

Colds, fever, dysentery, and others are regarded as natural sicknesses in which no spirit is involved. The Jivaros are very much afraid of contagious diseases. Whenever a man develops a cough or symptoms of some contagion the other Indians abandon the house and disappear into the bush, where they will have no contact with him. In the same way, they will avoid all persons who have been in contact with the sick person after he contracted his illness.

Many good photographs depict the Jivaro way of life, and the bulletin is well indexed.



POLITICAL ARITHMETIC. *A Symposium of Population Studies.*

Edited by Lancelot Hogben. Macmillan Company, New York. \$9.00. 9½ x 6; 531; 1938.

A collection of twelve papers by various members of the department of social biology of the University of London are presented in this volume together with two articles in the form of introductions written by the editor, Professor Hogben. In the first part of the book are included papers respectively by Kuczynski, Charles, and Glass, all dealing with certain aspects of human fertility. In part two, Gray, Moshinsky, Charles, Glass and Morgan are represented by papers on the general subject of education, income, and ability. An article on blood groups and race by Davis has been for some obscure reason included in this section. On the whole, these essays are all of a high standard and furnish additional information about studies already reported by the several authors. The main point of interest of this book is the introduction: *Prolegomena to Political Arithmetic*, by Hogben. In it he begins by recalling the great

contributions of William Petty to British demography and proceeds to discuss the subject of research in social sciences. He emphasizes, in particular, the need for more facts and for measures which will allow the practical utilization of the knowledge thus gained. All will agree in theory, at least, with the ideas expressed by Hogben although it is not quite clear why they should be couched in the bellicose terms he uses and why he should feel so strongly against Malthus and the so-called Austrian school of economists.



KAZAK SOCIAL STRUCTURE. *Yale University Publications in Anthropology Number 20.*

By Alfred E. Hudson. Yale University Press, New Haven; Oxford University Press, London. \$1.50. 9½ x 7; 109; 1938 (paper).

This brief monograph dealing with "certain features of Turco-Mongol social structure by an examination of some of the processes . . . in their development" is well put together. From field work and a study of the literature, the author has uncovered the story of a now sedentary people, the Kazaks, who once were nomadic stock-breeders, and who are descended from the invading armies of Chingis Khan in the 13th century. They inhabit the steppe country east of the Caspian Sea as far as the Altai Mountains. The customary tribal formation was occasionally altered when an enterprising son of some important family would strike out for himself with his herds and his dependents, such seceding groups coming to be considered as separate and independent tribes; at various times such small tribes became reunited under a strong leader. It was not until the 16th century, however, that a Kazak "nation" appeared. In the 17th and 18th centuries the Russians conquered them, and Kazakstan is now an autonomous republic within the Soviet Union.

The author concludes with a short discussion on the development of Mongol social structure, and its probable relation to Kazak culture.

DEATH ON THE INSTALLMENT PLAN.

By *Louis-Ferdinand Cline*. Translated from the French by *John H. P. Marks*. Little, Brown and Co., Boston. \$2.75. 8½ x 5½; 593; 1938.

Unless we are greatly in error this is an important book that will last. Because of the obscenity and filth with which its first half or so is heavily loaded, by evidently deliberate intent of its author to shock, it is a somewhat unpleasant and repulsive book. But dirty words are really in no wise essential to the author's basic purpose, which is to set forth a scientifically accurate account of the development of a human personality from childhood to adulthood, and the important circumstances of the environment, physical and biological, in which that development took place and by which it was influenced. The result is a great contribution to human biology as well as to literature. When one has read this book, and the *Pasquier Chronicle*—also written by a physician—one knows things about the French people that will never be forgotten and that no textbook of anthropology, ethnology, psychology, or biology has ever taught or is ever likely to. We strongly recommend this work to our readers, but couple with the recommendation the suggestion that they start their reading with Chapter II. Chapter I is only confusing and irritating, and has no significant relation to anything that follows in the book.

**THE PEYOTE CULT.** *Yale University Publications in Anthropology Number 19.*

By *Weston La Barre*. Yale University Press, New Haven; Oxford University Press, London. \$2.50. 9½ x 7; 188 + 2 plates; 1938 (paper).

This is a comparative and integrated treatment of the many studies that have been done on the peyote cult in individual tribes. The first chapters discuss the botanical and physiological aspects of peyote, a small cactus growing in the Rio Grand Valley and southward, whose salient characteristic is its production of visual hallucinations as well as kinaesthetic, olfactory, and auditory derangement. The study covers the ethnology of peyotism, and the use of peyote in reli-

gious rituals in various tribes in Mexico and, since about 1870, in the United States, particularly in the plains region where nearly all groups now use it. The last chapters deal fully with the psychological aspects of peyotism and its historical interpretations.

These compact pages are supplemented by long and numerous foot-notes, a fourteen-page bibliography and 9 lengthy appendices.

**THE AGRICULTURAL AND HUNTING METHODS OF THE NAVAHO INDIANS.** *Yale University Publications in Anthropology Number 18.*

By *W. W. Hill*. Yale University Press, New Haven; Oxford University Press, London. \$2.50. 9½ x 6½; 194 + 4 plates; 1938 (paper).

Among the Navaho Indians, hunting and agriculture were and still are the principal means of making a living. Intimately associated with both activities a complicated system of rituals and taboos has been developed. With a wealth of detail, the author describes the rites as well as the rationalizations and the technological characteristics with which they are associated. From his account it appears that the ceremonial and the practical aspects of the economic behavior are so well integrated that one aspect has become the necessary complement of the other. Moreover, it is seen that this adjustment has not been altered by the changes that the contact with the whites has produced in the technique of hunting and cultivating. The author has presented his observations in a straightforward and interesting manner and by this investigation has contributed to the little knowledge there is of the practical behavior of primitive peoples. There is an adequate bibliography.

**AN EXPERIMENT IN THE REGISTRATION OF VITAL STATISTICS IN CHINA.**

By *C. M. Chiao*, *Warren S. Thompson* and *D. T. Chen*. *Scripps Foundation for Research in Population Problems*, Oxford, Ohio. \$1.00. 8½ x 6½; [6] + 115; 1938 (paper).

As all students of population are well aware, the largest unknown quantity in the world's population is that of China. In 1930-31 Dr. Thompson, representing the Scripps Foundation, visited the University of Nanking, where he arranged with Dr. Chiao and Dr. Chen, of the University's Department of Agricultural Economics, for an actual registration of the vital statistics of a Chinese community of some 20,000 people. This jointly sponsored experiment was carried out in Hsiao Chi, a presumably typical area in the lower Yangtze delta. Detailed analyses of the data from this registration and from a census carried out in 1932 are now presented, relevant to nuptiality, natality, mortality, migration, and natural increase.

In an appendix on "The Outlook for the Improvement of Standards of Living in China," Thompson discusses the probability that the benefits of any agricultural and industrial progress will largely go to the support of more people, rather than to the improvement of living-standards in China.



FINLAND IN SUMMER.

By F. J. North. W. Haffer and Sons, Cambridge. 10s. 6d. net. $8\frac{1}{2} \times 5\frac{1}{2}$; xv + 233 + 76 plates; 1938.

This is a rather dull book, but like many other dull books it is full of desirable information about a country that is being increasingly visited by the foreigner. If the book is dull the Finnish people certainly are not, so we can promise the reader that *Finland in Summer* will give him an excellent background for a delightful visit to a country that is new as a state but old as a nation; where the people— young, middle-aged, and old—still cling to the habit of being industrious; where the trend in production is along modern lines yet a strong sense of the value of the arts and crafts as well as the traditions of long ago is maintained; where wood, in spite of the vast quantities of it that have been consumed in the production of foreign newspapers, is still abundant enough to be used by the railroads as fuel.

The volume is well illustrated and indexed and contains a useful bibliography.

OTHER MEN'S LIVES.

By Sir George Dunbar. Nicholson and Watson, Ltd., London. 10s. 6d. net. $8\frac{1}{2} \times 5\frac{1}{2}$; xi + 355; 1938.

Dunbar has attempted to furnish a panoramic view of the actual mode of living of primitive man. He begins by reconstructing from the relics uncovered a detailed picture of the daily life of prehistoric man, his food, shelter, art, and means of earning a living. From prehistoric man he passes to a survey of primitive peoples and summarizes some of the available information regarding Tasmanians and North American Indians. He concludes with a detailed report of his own observations on the Tibetan border tribes that have remained untouched by the civilizations of either Tibet or Assam. The whole book is well written, but this last section is the most interesting since it contains observations about peoples not generally discussed in anthropological literature. Technically a competent piece of work and well worth reading.



L'HYGIÈNE SOCIALE DES VILLES. I. L'URBANISME ET LE TRAVAIL SOCIAL. Bibliothèque de l'Institut d'Urbanisme de l'Université de Paris.

By R. H. Hazemann. Vincent, Fréat et Cie, Paris. $9\frac{1}{8} \times 6\frac{1}{2}$; 22; 1937 (paper).

It is generally accepted today that the problems of public health and economic welfare are closely intertwined. Hazemann, therefore, proposes the creation of health centers in every community, particularly the urban ones, in order to co-ordinate the efforts at disease control and social assistance. In this pamphlet a plan for such centers is presented together with an outline of the type of personnel desired and an estimate of the cost. In the main, the organization proposed does not differ materially either in scope or function from that evolved in hospital dispensaries and health districts of some of the large cities of this country. The principal exception is that the author expects the state to provide all the funds for such enterprises, because in his opinion the cost would always be much less than the present financial loss to the country caused by disease and illness.

THE NATURAL HISTORY OF POPULATION. *University of London Heath Clark Lectures 1937.*

By *Raymond Pearl*. Oxford University Press, London. 10s. 6d. Oxford University Press, New York, \$3.50. 8½ x 5½; xii + 416; 1938.

This book embodies the Heath Clark Lectures of 1937, together with much additional material relating to human fertility and factors that influence it. Some indication of the scope of the book is given by the chapter heads: Biological background; the biology of fertility; human and animal reproductive patterns; the extent of contraceptive efforts in the American population; the effects upon natural fertility of contraceptive efforts; world population, past, present, and future. Following the text are successively a section of notes; an appendix of statistical tables; an appendix describing methods by which the author's original data were collected; a bibliography of over 700 titles; an index.



THE HEALING KNIFE. *A Surgeon's Destiny.* By *George Sava*. Harcourt, Brace and Co., New York. \$2.50. 8 x 5½; x + 310; 1938.

The remarkable story of a young Russian who persevered until he attained his goal in life—to become a surgeon. From the time that he removed a bullet that was lodged dangerously on the pericardium of a fellow soldier (a pocket knife being his only surgical instrument) until he finally reached England's shores as an accredited surgeon, our hero worked in a morgue where he surreptitiously dissected cadavers during the night; earned his way through school working as a waiter; as a model; as a stoker; rode as a stowaway on a trans-continental train; and had two unfortunate romances. George Sava (a pseudonym) is indeed a fortunate person, for not only does he possess a surgeon's instinct, but he also enjoys psychic powers that stood him in good stead in times of stress. With these qualifications and experiences in addition to a rather pleasing literary style, the author has produced a readable book.

SHAMANISM IN WESTERN NORTH AMERICA. *A Study in Cultural Relationships.*

By *Willard Z. Park*. Northwestern University, Evanston and Chicago. \$2.25. 9 x 6; viii + 166; 1938.

A comprehensive study of shamanism among our western Indians providing much that has been lacking in comparative studies of Indian culture. Much credit is due Dr. Park for his untiring efforts in the field, and for his keen judgment in evaluating and classifying his materials. It is found that the shamanistic rites play an important rôle in the lives of the Paviotso Indians, especially in curing the sick and in charming game. From the careful first-hand study of the distribution of customs and institutions of shamanistic practice, the author suggests that the Paviotsos have had relations with tribes over a much wider area than had originally been supposed.

The volume is well indexed and contains a valuable list of bibliographic references.



VIVID EXPERIENCES IN KOREA.

By *Wm. H. Chisholm*. Foreword by *Howard A. Kelly*. Bible Institute Colportage Ass'n, Chicago. \$1.00. 7½ x 5; 136; 1938.

In this little book, Dr. Chisholm has recounted a series of characteristic incidents in the life of a medical missionary at his work in a foreign land, and has intimated in each of these the widespread need for medical and spiritual aid. The purpose of the publication has obviously been that of bringing to the public mind the fact that foreign peoples are entirely capable of receiving the Christian message, and that the work of a foreign medical missionary is successful in some measure at least in its purpose of winning souls.



BIBLIOGRAPHY ON LAND UTILIZATION, 1918-36. *U. S. Department of Agriculture. Miscellaneous Publication No. 284.*

By *Louise O. Bercaw*, *Annie M. Hannay* and *Mary G. Lacy*. Government Printing Office, Washington. \$1.50. 9½ x 5½; iv + 1508; 1938 (paper).

This companion volume to the *Bibliography on Land Settlement*, issued in 1934 as *Miscellaneous Publication* 172 by the United States Department of Agriculture, contains selected references to the literature on the economic aspects of land utilization and land policy in the United States and in foreign countries, published for the most part during the period 1918-36. "Relatively few references to the early land policies of the United States and of the individual states have been included, mainly because a bibliography on this subject is in preparation by the Bureau of Agricultural Economics." There is an index of authors and of subjects.



AMERICA'S COOK BOOK.

Compiled by The Home Institute of The New York Herald Tribune. Charles Scribner's Sons, New York and London. \$2.50. 8½ x 5½; xvi + 1006; 1938.

This is indeed a remarkable book. Its 1006 pages contain (besides something over 3000 recipes) practically everything one wishes to know about the buying and preparation of food, menu making (128 menus), table setting and serving, the herb garden, foreign recipes to the number of 138, etc. etc. Furthermore, it is so constructed that the recipe section stays open—one need not weight the pages. We had a somewhat superior feeling when two of our favorite American recipes could not be found herein.



THE ADOLESCENT PERIOD. *A Graphic and Pictorial Atlas*. Monographs of the Society for Research in Child Development. Volume III, Number 3. Serial No. 16.

By Frank K. Shuttlesworth. Society for Research in Child Development, National Research Council, Washington. \$1.00. 9 x 6; v + 246; 1938 (paper).

Contained in this volume are 440 graphs and 18 series of photographs touching on the diverse aspects of adolescent development. They depict the quantitative information collected by American investigators, particularly on the physical growth, health, physiology, behavior, intelligence, and economic and social

status of adolescents. Obviously any such enterprise as this can never achieve completeness, but the author deserves much credit for a compilation which will be found very useful for purposes of reference.



COMING INTO BEING AMONG THE AUSTRALIAN ABORIGINES. *A Study of the Precreative Beliefs of the Native Tribes of Australia*.

By M. F. Ashley-Montagu. Foreword by B. Malinowski. E. P. Dutton and Co., New York. \$5.00. 9½ x 6; xxxv + 362; 1938.

The American edition of a treatise already noted (Q. R. B., 13: p. 248) in these pages.



INFANT CARE. U. S. Department of Labor, Children's Bureau. Publication No. 8.

Government Printing Office, Washington. 10 cents. 9½ x 5½; iv + 107; 1938 (paper).



ZOOLOGY

THE SPRAT AND THE SPRAT FISHERY OF ENGLAND. Ministry of Agriculture and Fisheries. *Fishery Investigations, Series II*. Vol. XVI. No. 2.

By J. Armitage Robertson. H. M. Stationery Office, London. \$1.40. 10½ x 7½; 100; 1938 (paper).

THE ENGLISH PLAICE-MARKING EXPERIMENTS 1929-1932. *Fishery Investigations, Series II, Volume 16, Number 1*.

By C. F. Hickling. H. M. Stationery Office, London. 4s. (Obtainable in North America from British Library of Information, New York.) \$1.25. 10½ x 7; 84; 1938 (paper).

The English sprat fishery depends upon a coastwise immigration of shoals in winter, undertaken by adult fish in the early stages of sexual maturation. In the first publication here noticed, material—much of it illustrated with tabular data—is presented on the geographical distribution, specific characteristics, early life-history and development, age- and size-composition in adult shoals and in the

samples taken, sex-ratio, maturity and ripening of the gonads, stomach contents, fat yield, parasites and disease of the fish, and the economic and commercial status of the sprat-fishing industry.

The plaice marked in the experiments described in the second publication were liberated along the continental coasts from Horns Reef to the Haaks, in each of the years from 1929 to 1932. Most of the fish were recaptured near the position of liberation as late as in the third year after release. However, they did distribute themselves widely, the most rapid dispersion appearing to be in the late spring or summer. In a few cases where a significant difference between the sexes was found in the area of dispersion, the males were found more widely dispersed than the females. Likewise, larger fish dispersed themselves more widely than the smaller, and the older fish more widely than the younger. Of the plaice marked in any given experiment, those which wandered away from the coasts grew substantially more than those which were captured near the coasts. Growth rates of fish marked at the different stations, and at different seasons of the year, are noted.



THE MAMMALS OF CHINA AND MONGOLIA.
Natural History of Central Asia, Vol. XI,
Part 1.

By Glover M. Allen. *Central Asiatic Expeditions, American Museum of Natural History, New York.* \$10.00. 11 x 8½; xxv + 620 + 9 plates; 1938.

This report on the mammals of China and Mongolia is the fifth of a series of twelve volumes to appear on the biology and geology of Central Asia. The material is based on collections made during the American Museum's First and Second Asiatic Expeditions and the Central Asiatic Expeditions of 1921-1930.

All mammals (except the typical rodents, an account of which will appear in Part II) known or believed to occur in this area are described together with notes on their occurrence and habits. Keys to the genera and species, distribution maps, photographs, and a bibliography of 40 pages form part of this report. The

bibliography, incidentally, is for both Part I and II; the latter volume will include the index.

The similarity of the biota of northern North America and northern Asia is well known to zoogeographers, but south of the transcontinental evergreen forest belt this similarity is lost. "The obvious conclusion is that the former (northern latitudes) group owes its similarity to a more recent continuity of land area, while the latter group (southern latitudes) has been separated for a far longer period, allowing time for evolutionary changes in some types and the extinction or increase in others, with a resulting lack of similarity at the present time."

This monograph is of the first rank of quality and significance and together with the second part will form a lasting record for a region where such studies are not easily undertaken.



AFTER BIG GAME IN THE UPPER YUKON.

By Nevill A. D. Armstrong. *John Long, London.* 18s. net. 9 x 6; 287 + 16 plates; 1938.

In a previous book Major Armstrong related the most important and exciting adventures of his thirty-odd years in the Yukon. In this he describes in greater detail the hunting trips that he led in the upper Yukon region in 1914, 1925, 1926. They are the records of a genuine sportsman and an acute observer who can, moreover, make the reader enjoy the thrills and natural beauties he perceived and here depicts in vivid language. On one of these expeditions a new species of caribou was discovered and in this narration he includes notes on the habitat and life of this and other species of animals as well as antler measurements and a number of interesting photographs. An estimate of the cost of this type of expedition and advice on trapping methods are also given. After reading Major Armstrong's story it must be confessed that it is difficult to resist the invitation to visit this land which he considers the finest sporting country of its kind left on earth, a land of immense wilds with a glorious climate and abundant with game, birds and fish.

INSECTS OF CITRUS AND OTHER SUBTROPICAL FRUITS.

By Henry J. Quayle. Comstock Publishing Co., Ithaca, N. Y. \$5.00. 9 x 6; ix + 583; 1938.

This book will be of interest to all entomologists and horticulturists but especially to those having to do with the pests of citrus and other subtropical fruits. The author, long a student of these problems, has produced an authoritative work. Besides the citrus fruits, attention has been paid to insects attacking the avocado and other subtropical fruits such as the *Vinifera* grape, Persian walnut, almond, pecan, fig, olive, oriental persimmon, and pomegranate. The biology and economics of pest insects, their parasites, and predators have been fully treated. Much practical and specific advice is given to growers and their advisors, and the excellent bibliographies furnish useful references for entomologists, horticulturists, and ecologists. The numerous and excellent illustrations are a valuable addition to a work of this kind which concludes with a detailed index.

In reading this book we are once again impressed with the importance and need for "growth of population" studies on introduced organisms—whether it be bacteria, insects or men—or on organisms which have flourished, have died out and again have flourished in a particular locality.



THE SOCIAL LIFE OF ANIMALS.

By W. C. Allee. W. W. Norton and Co., New York. \$3.00. 8 x 5½; 293; 1938.

The account which Professor Allee gives here of some aspects of animal social behavior represents a semi-popular summary of the work done by himself and associates as well as by other students of the subject, presented as a series of Norman Wait Harris lectures at Northwestern University. Two fields of experimental work with which his name is particularly linked present the main topics for discussion; the effect of population size on the survival and growth of populations and individuals under specified conditions, and group organization

and behavior. The author describes the experimental procedures and results very clearly and in sufficient detail, and has succeeded in making the book an interesting as well as valuable contribution to the literature. The two final chapters on "Human implications" and "Social transitions" aim to correlate and integrate the animal observations and experiments with the problems of human sociality.

An important book, that will enhance its author's already high reputation in the field.



POULTRY HUSBANDRY. Second Edition.

By Morley A. Jull. McGraw-Hill Book Co., New York. \$4.00. 9½ x 6; vii + 548; 1938.

Neither the serious poultry breeder nor the amateur can afford to be without this book. It covers the field with great thoroughness, beginning with the breeds of chickens, the biology, breeding principles and practice, and continues with incubation and rearing, housing, feeding, disease, etc. The latter part of the book has to do with egg- and poultry-marketing problems, and the economics of production and marketing. Any one who masters the chapters on the biology of the chicken and on breeding principles and practices (and these chapters are written with great clarity) will be well equipped to enter the field of poultry husbandry. The book contains numerous illustrations, many tables, reference lists at the end of each chapter, and an excellent working index.



ОСНОВЫ ЭКОЛОГИИ ЖИВОТНЫХ.

Д. Н. Камбаров. Государственное Издательство медицинской литературы. Ленинград. 9 руб.45 коп. 602 стр. 1938.

[FUNDAMENTALS OF ANIMAL ECOLOGY.

By D. N. Kashkarov. State publishing house for medical literature. Leningrad. 9 roubles 45 kop. 602 pp. 1938.]

This is perhaps the most thorough textbook of animal ecology so far written. The first edition of it entitled "*Communities and Environment*" was published in the Russian language five years ago. The

second edition now under review is enlarged by approximately three times the original volume. There are fourteen chapters dealing with such topics as the subject of ecology, environmental factors, life zones, ecology of domesticated animals, biocoenosis, adaptation of animals from an ecological viewpoint and some others. The whole book impressively shows that ecology is a living and rapidly developing science with many problems of first-rate importance.



ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Volume XXIII, Part 2, Numbers 5-9.*

New York Zoological Society, Zoological Park, New York. \$1.45. 10½ x 7; 99-217; 1937 (paper).

The larger part of this number is devoted to the eighth report on the planktonic contents of nets drawn at various levels off the coast of Bermuda on the Bermuda Oceanographic Expeditions. This paper, by H. B. Bigelow, is on "Medusae taken during the years 1929 and 1930." No new species are reported, but information on the morphology of several has been extended and much has been gained from the distributional standpoint. There are included in the report 23 text figures, many tables giving data on morphological records and on distribution (horizontal and vertical), and a bibliography of 130 titles.

Other papers in the number deal with Classification of carp-like fishes; Tissue responses of *Cyprinodon variegatus* to the Myxosporidian parasite, *Myxobolus lineatus*; Electrical characteristics of the electric tissue of the electric eel, *Electrophorus electricus* (Linnaeus); and Colonial rattlesnake lore.



LES ARAIGNÉES.

By Lucien Berland. *Delamain et Bousselleau, Paris.* 15 francs. 7¼ x 4¾; xii + 175; 1938 (paper).

When it comes to writing books on nature, the French are incomparable masters. They seem to possess the knack of presenting facts in such a pleasant and unpedantic

manner that the reader forgets that he is not reading a novel and becomes absorbed in the unfolding drama of the natural world. Whether it is the French mind or the language which produces this effect, we don't profess to guess. In either case here we have the story of spiders, not only what they are and where they live, but also how they spend their lives, what they eat, and many other phases of their natural history as told by an authority on the subject in a most informal and delightful manner.



LITTLE LIVES. *The Story of the World of Insects.*

By Julie C. Kenly. Illustrated by Edna Reindel. D. Appleton-Century Co., New York and London. \$2.50. 8 x 5½; xviii + 271; 1938.

"There is a whimsical likeness between the lives of insects and the lives of men. They face many similar problems in a similar manner; and it is this angle of the matter I have chosen to stress in the following pages, for to personalize the little creatures is to bring them into clearer focus, while to see them on their own special plane is to change them on the instant into literary material."

One might become skeptical of the results, but the author has succeeded in separating fact from fancy and has consequently produced an engaging series of stories on various insects and spiders for those uninitiated in insect lore.



ANIMALS OF THE SEASHORE.

By Horace G. Richards. Bruce Humphries, Inc., Boston. \$3.00. 8 x 5½; 15 + 273; 1938.

To those who go to the shore only to bathe, to keep cool, and to fulfill social obligations this book will make no appeal. It is a strictly scientific work, couched in language that is simple without being childish, and illustrated by drawings and photographs culled from the publications of the leading scientific institutions of the east coast. With the help of this book the interested amateur can identify all the invertebrates he is likely to encounter at the Atlantic beach resorts. It will be especially appreciated

by beginners. The seven page index includes all scientific as well as popular names used in the text.



BIRDS AND MAMMALS OF MOUNT MCKINLEY NATIONAL PARK, ALASKA. *Fauna of the National Parks of the United States, Fauna Series No. 3.*

By Joseph S. Dixon. U. S. Government Printing Office, Washington, D. C. 35 cents. 9½ x 5½; xii + 236; 1938 (paper).

This is another of a series of faunal reports on the National Parks of the United States. An account of each species of bird and mammal is given in four parts bearing the following headings: general appearance, identification, distribution, and habits. Many interesting histories are found in this volume, especially those on the larger mammals with which this park is so fortunately favored. Photographs of the animals and of the park itself enhance the volume and give an indication of the beauty of these national resorts.



THE REPTILES OF OHIO.

By Roger Conant. The University Press, Notre Dame, Ind. \$2.00. 9 x 6; 200; 1938.

The author has been very careful to eliminate records of reptiles found in Ohio that in any way appear doubtful or obviously accidental. For this reason the list has been pared to thirty-nine species. Each of the species has detailed accounts of its occurrence in the state, its measurements and coloration, and notes on field observations made by the author. There are several plates of photographs and drawings, a bibliography, an index, and a glossary.



PARASITOLOGY. *With Special Reference to Man and Domesticated Animals.* [This book is a general revision of *Animal Parasitology*.]

By Robert Hegner, Francis M. Root, Donald L. Augustine and Clay G. Huff. D. Appleton-Century Co., New York and London. \$7.00. 8½ x 6; xxi + 812; 1938.

In this revised edition (first edition noticed in Q. R. B., Vol. 4, No. 4) the title has been changed to Parasitology for the reason that the title *Animal Parasitology* "appeared to be misleading, giving the impression that the parasites of man are not included." Owing to the death of Dr. Root, the section on medical entomology was revised by Dr. Huff, a former student of Dr. Root. The volume has, in every way, been brought up to date and many new figures have been added.



HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. *Lieferung 473. Abt. IX, Methoden der Erforschung der Leistungen des tierischen Organismus, Teil 7, Heft 5 (Schluss). Methoden der Tierhaltung und Tierzucht (Ergänzung zu Abt. IX, Teil 1).* Containing following articles: *Die Zucht- und Haltung von Säugetieren*, by Friedrich Kröning; *Das Halten und Züchten von Schlangen*, by Carl Stemmler-Morath; *Das Halten von Affen und Menschenaffen*, by Carl Stemmler-Morath; *Methoden und Ziel der Nachweisung der Ektoparasiten und Überträger von Invasionen und Infektionen der Haustiere*, by E. N. Pawlowsky.

Urban und Schwarzenberg, Berlin. RM. 15 (25 percent reduction in countries outside of Germany). 10 x 7; 224 + xx; 1938 (paper).

The first three papers contained in this *Lieferung* deal with the husbandry and breeding in the laboratory of small experimental mammals (rabbits, guinea-pigs, rats and mice), snakes, and monkeys and anthropoid apes. The last paper treats methods of collecting and identification of fleas, ticks, and other ectoparasites of domestic animals, together with some material on their life cycles and relation to the spread of infectious diseases.



CHARACTER IN FISH.

By Clifford Bower-Shore. Epworth Press, London. 1s. 6d. net. 6½ x 4½; 63; 1938. This tiny book, written by a sentimental lover and observer of fish, declares that

fish possess individuality and character and are capable of displaying emotion and intelligence above that which is instinctive. The author ends with a plea that those who endow dogs and cats with such "nauseating, sentimental regard" will look upon fish with a little more "understanding, sympathy and appreciation".



TURTLES OF THE CHICAGO AREA. *Zoology Leaflet 14.*

By Karl P. Schmidt. *Field Museum of Natural History, Chicago.* 25 cents. $8\frac{1}{2} \times 5\frac{1}{2}$; 23 + 2 plates; 1938 (paper). This leaflet is ideal for a quick identification of the turtles in the vicinity of Chicago. There is a key to the ten species as well as colored plates of the heads and black and white figures of the plastrons of each. Every naturalist who isn't sure of his turtles should have this pamphlet near at hand.



GENERAL ZOOLOGY. *Third Edition.*

By H. L. Wieman. *McGraw-Hill Book Co., New York.* \$3.50. $9\frac{1}{2} \times 6$; ix + 497; 1938.

The present edition has been almost entirely rewritten. Emphasis is put on the frog, especially in the early chapters of the book "with the idea of correlating the subject matter of the text more closely with that of the laboratory program."



CHARACTERISTICS AND CLASSIFICATION OF ANIMALS.

By E. Meiche and Marie Barrett. *General Biological Supply House, Chicago; Denoyer-Geffert Company, Chicago; E. Meiche, 115 Camp Street, San Antonio, Texas.* 50 cents. 23×17 ; 1 folding chart; 1938 (paper).

A small chart (17×23 inches) showing in condensed form the relationships, classification and chief characteristics of animals. It is designed to be used with any textbook, and should be helpful to teachers in beginning courses of zoology.

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN ZOOLOGY, Vol. 42, No. 27. *A New Trematode Paramphistomum castori* sp. nov., from *Castor canadensis baileyi* Nelson, from Mary's River, Nevada, by Charles A. Kofoid and James T. Park.

University of California Press, Berkeley. 25 cents. $10\frac{1}{2} \times 6\frac{1}{2}$; 4; 1937 (paper).

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN ZOOLOGY, Vol. 42, Nos. 3, 4, 5. *The Pterylosis of the Falconiformes with Special Attention to the Taxonomic Position of the Osprey*, by Lawrence V. Compton; *Geographical Variation in Wood Rats of the Species Neotoma fuscipes*, by Emmet T. Hooper; *Territory, Annual Cycle, and Numbers in a Population of Wren-Tits (Chamaea fasciata)*, by Mary M. Erickson.

University of California Press, Berkeley. No. 3, 50 cents; No. 4, 35 cents; No. 5, \$1.25. $10\frac{1}{2} \times 6\frac{1}{2}$; No. 3, 40; No. 4, 33; No. 5, 88; 1938 (paper).

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN ZOOLOGY, Vol. 43, Nos. 1, 2, 3, 4, 6, 7, 8. *The Devescovinid Flagellates Caduceia theobromae* França, *Pseudodevescovina ramosa* new species, and *Macrotrichomonas pulchra* Grassi, by Harold Kirby, Jr.; *The Life Cycle of Zygosoma globosum* sp. nov., a Gregarine Parasite of *Urechis caupo*, by Elmer R. Noble; *New Subgenera and Species of Diaptomid Copepods from the Inland Waters of California and Nevada*, by S. F. Light; *Brackish and Fresh-Water Nereidae from the Northeast Pacific, with the Description of a New Species from Central California*, by Olga Hartman; *Descriptions of New Species and New Generic Records of Polychaetous Annelids from California of the Families Glyceridae, Euniciidae, Stauronereidae, and Opheliidae*, by Olga Hartman; *Comparative Ecological Studies on the Terrestrial Isopod Crustacea of the San Francisco Bay Region*, by Milton A. Miller; *The Development of the External Form of the Rat, with Observations on the Origin of the Extraembryonic Coelom and Foetal Membranes*, by J. A. Long and Paul L. Burlingame.

University of California Press, Berkeley.

No. 1, 50 cents; Nos. 2, 6 and 7, 35 cents each; Nos. 3 and 4, 25 cents each; No. 8, 65 cents. $10\frac{1}{2} \times 6\frac{1}{2}$; No. 1, 40; No. 2, 26; No. 3, 12, No. 4, 4; No. 6, 20; No. 7, 30; No. 8, 42; 1938 (paper).

TRANSACTIONS OF THE SAN DIEGO SOCIETY OF NATURAL HISTORY, Vol. 8, Nos. 33 and 34. *New and Obscure Decapod Crustacea from the West American Coasts*, by Steve A. Glassell; *A Study of the Skull of the Pleistocene Stork, *Ciconia maltha**, Miller, by Loye Miller.

Society of Natural History, San Diego, Calif. 10½ x 6½; No. 33, 44; No. 34, 4 + 1 plate; 1938 (paper).



BOTANY

SOILLESS GROWTH OF PLANTS. *Use of Nutrient Solutions, Water, Sand, Cinder, Etc.* By Carleton Ellis and Miller W. Swaney. Reinhold Publishing Corporation, New York. \$2.75. 9 x 6; 155; 1938.

The difference between plant and animal alimentation consists chiefly in that while animals are dependent for their food supply on plants and other animals, plants in general have the ability to utilize the energy of sunlight in building up food stuffs from carbon dioxide from the atmosphere and certain inorganic mineral salts from the soil. The question naturally arises as to whether if a plant be supplied with adequate mineral substances in a readily assimilable form, it might not be able to dispense with the soil altogether, except as a means of physical support. For some years past the authors of this work have been experimenting in this direction. As experience accumulated they have succeeded in demonstrating to their own satisfaction at least, that the growth of plants in nutrient solutions is entirely practicable. The few instances where they have not succeeded may reasonably be attributed to the lack of suitable ingredients in the solution rather than the method *per se*.

The question that will come at once to the mind of every reader is, as these authors recognize, whether their experimental results imply that the farmer of the future will harvest his corn crop from a row boat. Such a contingency is by no means impossible but at the present time seems too remote to afford safe speculation. But greenhouse culture is a different thing. One of the big items in the expense of running a greenhouse is the

renewal of the soil, which must be done at least once a year. By dispensing altogether with the soil a great saving may be effected, and wherever soilless culture in the greenhouse has been tried it has proved an economic success.

The book is brief but it is thorough and while the index covers only five pages it is adequate. The illustrations are from photographs taken by the authors.



A TEXTBOOK OF GENERAL BACTERIOLOGY. *Twelfth Edition, Revised.*

By Edwin O. Jordan. Revised by William Burrows. W. B. Saunders Company, Philadelphia and London. \$6.00. 9½ x 5½; 808; 1938.

AIDS TO BACTERIOLOGY. *Sixth Edition.*

By William Partridge. Revised by H. W. Scott-Wilson. William Wood and Co., Baltimore. \$1.50. 6½ x 3½; vii + 300; 1938.

A TEXTBOOK OF BACTERIOLOGY. *Second Edition, Revised.*

By Thurman B. Rice. W. B. Saunders Company, Philadelphia and London. \$5.00. 9½ x 5½; 563; 1938.

To Dr. Burrows, student and associate of the late Dr. Jordan, fell the task of revising the present edition of his textbook (cf. Q. R. B., Vol. 11, p. 106 for previous review) which, in the last thirty years, has gone through twelve editions. Perhaps the most extensive revision has been made in the chapter on virus diseases. The sections on oxygen supply and respiration, on filtration and isolation of bacteria in pure culture have been entirely rewritten, and many other changes and additions have been made, in line with recent developments of the subject.

Considerable revision has been made in the second of these texts especially in the sections concerning streptococci, the colityphoid groups, *Neisseria*, and the filtrable viruses; also in the sections dealing with standard methods of water and milk analyses and the standard method for performing the Rideal-Walker test. New sections deal with the bacteriology of swimming baths and the numerous new methods of laboratory diagnosis.

In the last revised text (first edition reviewed in Q. R. B., Vol. 11, p. 104) the

author has held to his original plan of presenting a relatively simple text of such size that the student can master it in one semester. Changes have been made only to bring the text up-to-date, to fill certain omissions or to correct inaccuracies and to improve or clarify certain passages.



HERBALS: Their Origin and Evolution. *A Chapter in the History of Botany 1470-1670. A New Edition Rewritten and Enlarged.*

By Agnes Arber. *The University Press, Cambridge; The Macmillan Co., New York.* \$7.50. 9½ x 6½; xxiv + 326 + 27 plates; 1938.

Mrs. Arber's delightful book on the evolution of the printed herbal first appeared in 1912 but has long since been unobtainable. It now reappears in new form, very much rewritten and enlarged.

A herbal has been defined as a book containing the names and descriptions of herbs, or of plants in general, with their properties and virtues. After the invention of printing, and during the years 1470 to 1670, there was much activity in the production of such works, and many old, and some very old, manuscripts were published along with numerous more recent studies. It is of this evolutionary period of the herbal, covering about two hundred years, that the author so entertainingly writes. Little attempt has been made to enter the field from the gardening or medicinal aspect, the subject being primarily treated from a botanical standpoint and secondarily from an artistic approach.

Since the first edition of this book appeared much new material has come to light and the author has taken full advantage of these researches. Much has been added concerning botany in Spain and Portugal and the origin of herbaria. The list of references has been greatly extended and is arranged in two appendices—(a) A chronological list of the principal herbals and related botanical works published between 1470 and 1670, and (b) An alphabetical list of the historical and critical works consulted during the preparation of this book. The illustrations showing portraits of the authors of the herbals and many of their plant drawings add greatly to the interest of the book. Excellent indexes are included.

PLANT HUNTER'S PARADISE.

By F. Kingdon Ward. *The Macmillan Company, New York.* \$3.50. 7½ x 5½; 347; 1938.

The experiences of more than a year's exploration in northern Burma, Assam, and south-eastern Tibet have been carefully recorded by Mr. Ward in this interesting volume. Throughout the book the author has continuously emphasized the beauty and grandeur of the native flora, and has described in some detail the new species encountered. The journey was made for a two-fold purpose: (1) to discover, if possible, the source of the Irrawaddy river; and (2) to collect native flora and fauna. Ward and his partner Cranbrook were so interested in making their collections of flora and fauna, respectively, that the problem of the source of the Irrawaddy became of secondary importance and was dismissed with a guess and the statement that "the possibilities of its source are so limited that the problem is of academic interest only."

Mr. Ward's style of writing is so captivating that one finds it difficult to put the book down after once starting read it. The text is generously supplied with photographs depicting native scenery and inhabitants of the lands traversed. The book is concluded by appendices (1) The stages of the journey, distances, and method of transport; (2) Weather; (3) Zoology; and (4) Plants introduced from far northern Burma.



FOREST PATHOLOGY.

By John Shaw Boyce. *McGraw-Hill Book Co., New York.* \$5.00. 9½ x 6; ix + 600; 1938.

A well-planned and well-executed book. In a work of this type where space is limited but the subject an important one with many angles, the author is always plagued by numerous questions concerning what to include and what to exclude in the text in order to create a useful, up-to-date guide. Boyce, Professor of Forest Pathology at Yale, says in his preface:

... conditions change, so that a disease which now seems important may in time be relegated to a minor position. On the other hand, with American chestnut approaching commercial extinction, justification for a detailed treatment of chestnut blight is

that the discussion becomes a historical record of the behavior of a virulent introduced parasite, a record which may be valuable in connection with the behavior of future introduced diseases.

The general scheme of the book can best be indicated by listing a few of the subjects discussed in the order in which they occur, following the introductory chapters on disease, fungi, and non-infectious diseases:—seedling diseases, root diseases, foliage diseases of hardwoods and of conifers, stem diseases (8 chapters), rots, etc. The volume is well illustrated and documented, contains a section on fungicides, a list of common names of plants used with scientific equivalents, and a detailed index.



MANUEL OF PTERIDOLOGY.

Edited by Fr. Verdoorn et al. Foreword by F. O. Bower. Martinus Nijhoff, The Hague. Gld. 24. 9 $\frac{3}{4}$ x 6 $\frac{1}{2}$; xx + 640; 1938.

This manual, in its aims as well as in method of treatment, follows closely the same editor's well-known *Manual of Bryology*. It

is primarily, but by no means exclusively, designed for the taxonomist who is anxious to improve his methods and broaden his outlook. At the same time it offers to the general botanist working on the Pteridophytes the necessary fundamental facts about the group and a survey of the chief results of lines of investigation related to his own. . . . certain branches of the subject are dealt with more fully, because no good surveys of them have been published.

No attempt has been made to make this an exhaustive treatise. The twenty-three sections, each dealing with some special phase of the Pteridophytes, are rather a collection of essays written by specialists. There are many illustrations throughout the volume, it is well documented and indexes of plant names and personal names are included. A valuable reference book.



DAS PHYTOPLANKTON DES SÜSSWASSERS. *Systematik und Biologie.*

By G. Huber-Pestalozzi. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. (In Germany) RM. 42 (paper); RM. 44 (cloth); (Outside of Germany) RM. 31.50 (paper); RM. 33 (cloth). 10 x 6 $\frac{1}{2}$; [6] + 342 + 66 plates; 1938.

After a general discussion of 125 pages of plankton invasion, types of phytoplankton, chemical considerations, theories of suspension, plankton parasites, preservation, etc., the author presents a systematized catalog, with descriptions, geographical distribution, specific distribution with regard to position in the water, and any other known biological information of the phytoplankton of lakes, ponds, swamps and other small fresh-water bodies throughout the world. Bacteria and fungi are included, the sections on these being provided with separate bibliographies. There are also author and subject indices for the separate parts. A valuable contribution by an authority in the field.



A COLLEGE TEXTBOOK OF PHARMACEUTICAL BOTANY. *Sixth Edition.*

By Heber W. Youngken. P. Blakiston's Son and Co., Philadelphia. \$4.75. 9 x 6; xxviii + 793; 1938.

This revision, which includes changes in and reorganization of some of the chapters and the addition of 121 new figures, has been so made as to present a "broad general treatment of botany with particular stress upon those phases of this science such as histology, cell contents, taxonomy, and medicinal plants which are believed to be most helpful in preparing students to cope with botanical problems in pharmacognosy and in the practice of pharmacy."



PLANT PHYSIOLOGY. *Second Edition.*

By Nicolai A. Maximov. Edited by R. B. Harvey and A. E. Murneek. Translated from the Russian by Irene V. Krassovsky. McGraw-Hill Book Co., New York and London. \$4.50. 9 x 6; xxii + 473; 1938.

This is a completely new book—the first edition (cf. Q. R. B., Vol. 6, No. 2) bore the title "Textbook of Plant Physiology"—bringing up to date the results of plant physiological research throughout the world. It is based on the translation of Dr. Maximov's fifth Russian text. The editors have introduced data and view-

points from recent American publications, revised the discussion, and amplified the presentation of the original author.



BOTANICAL STUDIES IN THE BLACK ROCK FOREST. *The Black Rock Forest Bulletin* No. 7.

By Hugh M. Raup. *Black Rock Forest, Cornwall-on-the-Hudson, N. Y.* \$1.50. 9 x 6; vi + 161; 1938 (paper).



MORPHOLOGY

A TEXT-BOOK OF HISTOLOGY. *Functional Significance of Cells and Intercellular Substances.* Second Edition, Thoroughly Revised.

By E. V. Cowdry. Lea and Febiger, Philadelphia. \$7.00. 10½ x 6½; 600; 1938.

A TEXTBOOK OF HISTOLOGY. Third Edition, Completely Revised.

By Alexander A. Maximow and William Bloom. W. B. Saunders Company, Philadelphia and London. \$7.00. 9¾ x 6¼; xv + 668; 1938.

AIDS TO HISTOLOGY. Fourth Edition.

By Alexander Goodall. William Wood and Co., Baltimore. \$1.25. 6¼ x 4; viii + 151; 1938.

In the preface to the second edition of Dr. Cowdry's excellent text (cf. review of first edition, Q. R. B., Vol. 10, No. 2) the author cheerfully lists the objections (contributed by his friends upon request) to the first edition and outlines the changes herein made. The introductory chapter is partly historical, no attempt being made to summarize histological details. "The whole book is an introduction to histology. Each and every system, and even their more important parts, are introduced individually immediately before the students become acquainted with them. Sometimes a few words suffice. Entire chapters are devoted to introducing the endocrines and the digestive system." We like the following statement: "The level of the presentation has not been lowered. To cater to the least informed members of the class is not our purpose." Many figures have been added including several which illustrate the histological changes in the process of ageing.

Previous reviews of the second of these

texts have appeared in Vol. 6, p. 242, and Vol. 10, p. 110 of this journal. Professor Bloom has ably prepared the present edition of the late Dr. Maximow's book which has required considerable revision and many additions.

The fourth edition of Dr. Goodall's little book (in which the essential facts of histology are presented "in small compass as a guide to the junior student") has been revised and in part rewritten. New work on ossification, haematology, and the ductless glands has been incorporated.



AN INTRODUCTION TO VERTEBRATE ANATOMY.

By Harold M. Messer. The Macmillan Co., New York. \$3.50. 8½ x 5¾; xvi + 406; 1938.

MANUEL FOR COMPARATIVE ANATOMY.

By Leonard P. Sayles. The Macmillan Co., New York. \$1.60. 10 x 7½; xi + 214; 1938.

LABORATORY DIRECTIONS FOR COMPARATIVE VERTEBRATE ANATOMY.

By I. E. Gray. P. Blakiston's Son and Co., Philadelphia. \$1.00. 9¾ x 6¼; x + 80; 1938.

The first text further swells a long list of mediocre vertebrate anatomy books. There is doubtful wisdom in writing such a book for a one semester course, involving the omission of material necessary to pre-professional students of biology. Thus fifteen pages are devoted to reproduction and early vertebrate development, one page to cranial nerves and one to the anatomic system. The volume contains a good glossary and index. Photographs of amphibians, reptiles and mammals show these forms well, but the drawings are generally poor.

Mr. Sayles' book contains several qualities looked for in a good laboratory manual. It gives detailed descriptions of the shark, pidgeon, and cat, bringing in other forms for comparative purposes in the study of certain systems. The names of the various structures and their important parts are printed in bold-faced type on the left margin, facilitating the students' work. Frequent drawings depict those structures that are usually difficult for pupils to locate.

The short manual by Dr. Gray is intended for a half-year course, and presents only the barest essentials. Each organ system is completed in three forms, *Squalus*, *Necturus*, and *Felis*, before proceeding to the next system. There are neither drawings nor indices.



HANDBOOK OF HISTOLOGICAL AND CYTOLOGICAL TECHNIQUE.

By R. R. Bensley and S. H. Bensley. University of Chicago Press, Chicago. \$2.00. 11 x 8½; viii + 167; 1938.

Students who have been fortunate enough to learn the art of slide-making at first-hand from Professor Bensley have wished for a single published account of his methods; and students who have had no such good fortune—practising the art perforce without benefit of Bensley—have even more reason to wish for a comprehensive account of his techniques. And here it is, at long last. Here, in a handbook designed particularly for beginners, and containing therefore much that is conventional as well as much that has been specially devised in the anatomy laboratories at the University of Chicago, are some of the original, unpublished methods of Dr. R. R. Bensley. Being an introductory laboratory guide, this handbook deals of course with protoplasmic units as large as cells and tissues, but it seeks to lay its main emphasis on the sub-cellular constituents of living matter, in the investigation of which the author has been a pioneer.

Credit for the compilation of these methods adopted, developed, and devised in Dr. Bensley's laboratory is evidently intended to go solely to his daughter-in-law, who is an instructor in the laboratory in which the senior author is now professor emeritus. Her name, at any rate, appears alone after the preface.



THE PRIMATE THALAMUS.

By A. Earl Walker. University of Chicago Press, Chicago. \$3.00. 9 x 6; xxiii + 321; 1938.

In his research on the thalamus, its gross

and nuclear structure, its afferent connections, its relationship to the cerebral cortex, and the relationship of the geniculate bodies to the cerebral cortex, the author used the macaque monkey (*Macaca mulatta*) as his experimental material. The author's purpose is to elucidate the rôle of the thalamus in sensation, and this particular subhuman primate was selected for experimentation "because its thalamus is representative of the primate series and in many ways comparable to that of man".

Although the greater part of the monograph is devoted to the elucidation of the thalamocortical connections, the many experiments include all of the various relationships and connections of the thalamus. Also, the author reviews in great detail, its anatomical, physiological, and clinical significance.

In addition to a brief historical introduction, the text proper carries an extensive review of past and current literature. The monograph is profusely illustrated, and the extensive bibliography is divided, according to subject matter, into seven parts, each of which is placed with its respective chapter. There are two indices—author and subject.



OREILLE INTERNE. *Etude anatomo-pathologique et clinique. Technique histologique et expérimentale.* 2^e Edition.

By Ch. Clauot. Editions N. Maloine, Paris. 30 francs. 10 x 6½; x + 227; 1938 (paper).

The inner ear is so complex a structure that throughout the world there are only a few men who are really familiar with its anatomical and pathological characteristics, and fewer yet have any adequate knowledge of its physiological function. The condensed description of the anatomy, pathology and histology of the inner ear as given here bring out more than anything else this state of ignorance. Written very clearly but with only passable illustrations this monograph will serve to give the otologist as well as the anatomist some idea of what it is all about. More than that it cannot do because the author has limited himself to the usual general

textbook statements and although he cites the fundamental literature on the subject, has omitted all references to the studies of the past decade, particularly those made in this country.



SURFACE AND RADIOLOGICAL ANATOMY.
For Students and General Practitioners.

By Arthur B. Appleton, William J. Hamilton and Ivan C. C. Tchaperoff. William Wood and Co., Baltimore. \$5.50. 9½ x 6½; xi + 311; 1938.

The aim of this book is to provide an introduction to the study of features which are accessible to examination in the living subject. Besides the use of physical examinations, the authors have added radiology and have attempted, by the use of extensive illustrations, "to supply a means of coördinating radiological anatomy with those features which can be determined by external examination and with those details which can be determined only by dissection."

The more complex radiographs are supplemented by anatomical drawings to facilitate their interpretations. The book is divided into five sections, each describing certain areas of the body. There are several blank pages for notes as well as an appendix on ossification and one on muscle innervation. A useful treatise.



PHYSIKOCHEMISCHE GRUNDLAGEN DER HISTOLOGISCHEN METHODIK.

By K. Zeiger. Verlag von Theodor Steinkopff, Dresden and Leipzig. RM. 10.50 (paper); RM. 11.25 (cloth). 8¾ x 6; xi + 202; 1938 (paper).

This volume of the *Wissenschaftliche Forschungsberichte*, edited by R. E. Liesegang, is an important contribution bringing together the most important and definitive published material on the physical and chemical factors underlying histological techniques. It is profusely documented, mostly with the work of investigators of continental Europe, although English and American authors are also represented. An author index and a very comprehensive table of contents have been provided. It should be useful as collateral reading.

AIDS TO EMBRYOLOGY. Third Edition.

By Richard H. Hunter. William Wood and Co., Baltimore. \$1.25. 6¼ x 3½; vii + 178; 1938.

In the revision of this little book (cf. notice of second edition in Q. R. B., Vol. 10, No. 3) the general arrangement has been retained and it remains a short account of the more important changes which are known to occur in development. The descriptions are so arranged that the student will learn quickly to appreciate the signification of the common abnormalities found in the dissecting rooms and of those anomalies of development which are seen in the obstetrical wards."



PRACTICAL ANATOMY OF THE RABBIT. An Elementary Laboratory Text-Book in Mammalian Anatomy. Sixth Edition.

By the late B. A. Bensley. Revised and edited by E. Horne Craigie. P. Blakiston's Son and Co., Philadelphia. \$3.00. 8½ x 5¾; 320; 1938.

In the revision of this well-known text (cf. Q. R. B., Vol. 2, No. 3 for previous review) Professor Craigie has kept the essential features unchanged but has carried out rather extensive revision in order "to make the text easier for the beginner to understand while, at the same time, making it more complete, more precise, and more up to date."



PHYSIOLOGY AND PATHOLOGY

DIET AND CANCER: An Experimental Study.

By N. Waterman. D. B. Centen's Uitgevers-Maatschappij, Amsterdam. Fl. 4.25 (\$2.50). 9½ x 6½; 96; 1938.

The question of nutrition can no longer be neglected in cancer research. This question can, in the author's opinion, never be solved by social and clinical observations but only by experimentation. The effect of different diets should be studied on animals developing tar cancer. Experiments dealing with transplanted tumors cannot possibly give information about spontaneous tumor formation. With tar cancer the effect of diet on both

carcinogenesis and course of the process can be studied. Therefore the author made a series of experiments with mice developing cancer after tarring and reached the following conclusions: (1) One must distinguish between the substances favoring the outbreak of carcinoma and those increasing malignancy. Applied to human conditions this means that prophylactic and therapeutic diets do not necessarily coincide. (2) The value of the metastasis incidence cannot be stated easily. A method is described which will express numerically the metastasis incidence in its relation to the degree of malignancy. (3) Among the classical foodstuffs (proteins, carbohydrates, and fats) only the animal fats seem to have a frankly deleterious effect; the unfavorable influence of cholesterol seems to be due to the cholesterol ethers. (4) As regards the vitamins, a comparison between the action of vitamin A or the provitamin (carotene) in arachis oil and that of the same provitamin in olive oil shows that one has to be very careful in vitamin experiments, as the vehicle may be far from indifferent. Carotene in arachis oil seems to have a favorable effect and would especially appear to diminish the metastasis number; this was not the case when carotene was dissolved in olive oil. The unfavorable effect of vitamin B₁ as described in the case of inoculated tumors is certainly not present in tar cancer. Vitamin C appears to be distinctly favorable; therefore, these results are far from supporting the notion of a tumor-favoring action of tomato juice, which contains considerable quantities of vitamin C. Further experiments on the subject are to be published soon.



NUTRITIONAL PHYSIOLOGY OF THE ADULT RUMINANT.

By Ernest G. Ritzman and Francis G. Benedict. *Carnegie Institution of Washington, Washington.* \$2.00 (paper); \$2.50 (cloth). 9½ x 6¾; vi + 200 + 3 plates; 1938.

By converting coarse fodders into meat and milk, the ruminant intermediates (ecologically) between man and certain

humanly inedible plant sources of human food. We are told that man's exploitation of the Herbivora, and primarily of the ruminants, made possible the great numerical expansion of the human race. But, as the human population has become more dense, the population of husbanded livestock has met with increasing competition for its position, both as a consumer of cereal crops, and as the chief source of a concentrated food supply for man. The nutritional problems of today are different from those of our pioneer condition. Milk and meat we still need, and the finished animal products can be transported to market more cheaply than their ingredient feedstuffs; but the animal products are a much more costly form of human food than the raw cereals from which they are produced. The animal nutritionist must seek nowadays not only "the full potential nutritive values of the different feedstuffs," but also, and perhaps as a prerequisite, "the physiological susceptibilities of the animal itself to function as a machine under various exigencies of the food supply."

All that is a large order. Benedict and his colleagues have contributed numerous publications to the science of nutrition: in the present monograph they are concerned with the animal as a converter of energy, and also with the relation of the feedstuffs to the specific productive functions of the organism. They find that the basal metabolism of ruminants is extraordinarily variable, and that both proteins and carbohydrates have a stimulating effect on the metabolism. The components of the protein feeds is not discussed, nor is the work of Artturi Virtanen mentioned (see his "Cattle Fodder and Human Nutrition," Cambridge University Press). The present work is mainly concerned with a thesis on basal metabolism.



THE BASIS OF TISSUE EVOLUTION AND PATHOGENESIS.

By Albert A. Gray. *Jackson, Son and Co., Glasgow.* 7s. 6d. 9½ x 5½; xix + 92; 1937.

The significance of some books is made as evident by the circumstances of their

publication as by their contents. This brief theoretical work, published posthumously by the author's younger son, presents the evolutionary reflections of a medical man better known for his researches on the anatomy and diseases of the ear. It outlines a theory of *induced variation*, and the evidences from otology in its support.

The evolution of a tissue, structure, or organ is hypothesized to be the result of variation occurring during the repair which follows the minute injury of a tissue already in existence. The injury is caused by a change, greater or less, in the environment, and either constantly present or present repeatedly over a very long period of time. Accompanying this tissue evolution there is a corresponding evolution of the vasomotor response in the minute arterioles and capillaries of the injured part. As generation succeeds generation, natural selection preserves "those individuals in which the fertilized ovum has the greatest potentialities for rapidly developing that tissue or structure best suited to respond to the changed environment" and, concomitantly, for developing the appropriately responding vasomotor systems. Both the new tissue and its accompanying means of nutrition become in this way involved in the common inheritance of the species, the tissue character and its vasomotor support being both subject to genetic variation.

Examples are found in the organ of hearing: an example of inheritance of defect of structure in inherited deaf-mutism, and an example of inheritance of defect in the vasomotor response in inherited otosclerosis. The theory is derived from the author's otological investigations, which then are used for exemplification.



VITAMIN B₁ (THIAMIN) AND ITS USE IN MEDICINE.

By Robert R. Williams and Tom D. Spies.
Macmillan Company, New York. \$5.00.

9½ x 6; xvi + 411; 1938.

Among the multitude of books which demand attention nowadays, it is a satisfaction to come occasionally upon one which penetrates to the present limits of

knowledge. Williams and Spies seem to have written a solid, thorough work. This book aims to encompass everything that is known about thiamin, its chemical nature, and its physiological utilization.

The book is not an account of the whole vitamin B complex, of course: it deals with only one component. To make this clear, the authors present an ingenious frontispiece—a figure of an unraveling end of rope, four dated strands of which represent the isolated and synthesized components of the complex known as vitamin B. One of these is the vitamin B₁ or thiamin. The unknown factors of vitamin B are differentiated as far as they can be in the remaining strands of the rope.

The opening of chapter xi is quotable here. "It is doubtful whether the isolation and identification of any other substance in the history of biochemistry have cost as much labor as have these operations as applied to thiamin. The first gram of the pure vitamin must have cost an aggregate of several hundred thousand dollars. To mention all the names of those who have participated in some phase of the project is to call the roll of half the mature biochemists in England and the United States" as well as the Dutch, French, Japanese, German, and other contributors. Due credit to this legion of workers is given in the bibliographies at the ends of the chapters.



THE DOCTRINE OF SIGNATURES. *A Defence of Theory in Medicine.*

By Scott Buchanan. Harcourt, Brace and Co., New York; Kegan Paul, Trench, Trubner and Co., London. \$2.75. 8½ x 5½; xiv + 205; 1938.

If this reviewer is typical of other physicians—the group whose thinking and methodology the thesis of the book is intended to modify—the book is destined to colossal failure. After struggling through 200 pages of verbiage and obscure sentence structure, the author's argument emerged, only however as through a mirror darkly. It seems that the tradition of modern medicine, rooted in its ancient heritage, has been until recent times dominated by two men, one a philosopher

(Aristotle) and one a physician (Galen). The modern development of natural science has, in some way not made quite clear to this reviewer, "revised the tradition". Two possibilities suggest themselves to the author: "—to smash the tradition and allow the full play of the laboratory", or—the choice of the author—" . . . to recover the doctrines of the tradition". To do this the author suggests two steps. The first step is to rebuild the non-mathematical structures of the natural science, and cannot be taken, "except by a genius, without a thorough knowledge of Aristotelian logic, metaphysics and physics." The second step is "even more difficult", i.e. the "rationalizing of modern science as it actually goes on." The writings of Galen are suggested as a model.

We are neither amused nor instructed by this verbose and feeble attempt to revive the authoritarian obscurantism of the Dark Ages.



TEXTBOOK OF COMPARATIVE PHYSIOLOGY.
Second Edition.

By Charles G. Rogers. McGraw-Hill Book Co., New York and London. \$5.50. 9 x 6; xviii + 715; 1938.

AN INTRODUCTION TO HUMAN PHYSIOLOGY.
Second Edition, Revised.

By Lathan A. Crandall, Jr. W. B. Saunders Co., Philadelphia and London. \$2.00 7½ x 5½; 356; 1938.

A TEXTBOOK OF GENERAL PHYSIOLOGY FOR COLLEGES. *Third Edition.*

By Philip H. Mitchell. McGraw-Hill Book Co., New York and London. \$6.00. 9 x 6; xviii + 853; 1938.

LABORATORY MANUAL OF GENERAL PHYSIOLOGY. *First Edition.*

By Philip H. Mitchell and Ivon R. Taylor. McGraw-Hill Book Co., New York and London. \$1.50. 9 x 6; xv + 142; 1938.

The major part of the first of these books listed (cf. Q. R. B., Vol. 2, No. 4 for mention of first edition) has been rewritten in order to incorporate all the important advances which have been made since the earlier edition appeared. In its new form it is more the nature of a textbook and less

of a handbook for investigators. Much material is here presented for the first time in textbook form.

The new edition of the Crandall text (first edition noted in Q. R. B., Vol. 10, No. 2) adheres to the original plan of presenting the fundamental principles of physiology in such a way that the student beginning his college course will not be lost in a mass of detail and will acquire a thorough working knowledge of the behavior of the body as a whole and of the function of its parts. The revision consists of changes where necessary and the addition of new material.

Extensive changes in the third book listed (cf. second edition, Q. R. B., Vol. 8, p. 233) have been made, especially in connection with excitation, contraction, chemical transmission, structure of membranes, the permeability of cells, physiological oxidations, the chemistry of muscle, the vitamins and the hormones. There are new sections on the organizers or evocators, oxidation-reduction potentials, Liesegang phenomena, and the physiological study of temperature characteristics.

The manual of experiments is planned for use in connection with the textbook by Mitchell, but it may well be used with any other physiology text in developing a first year course. The number and variety of problems is such that the manual may be adapted to suit the method and interest of any professor, as well as the needs of any class of students. The book is well illustrated and indexed.



THE CULTURE OF ORGANS.

By Alexis Carrel and Charles A. Lindbergh. Paul B. Hoeber, Inc., Medical Book Department of Harper and Bros., New York. \$4.50. 9½ x 6½; xix + 221 + 38 plates; 1938.

It seems likely to this reviewer that every interested reader of American newspapers and news periodicals must have heard of this book by now. It has been most widely noticed. It is chiefly a description of an apparatus (notably the Lind-

bergh pump) and of a technique (notably Dr. Carrel's) by means of which whole organs have been cultured *in vitro* after isolation from an organism. The achievement of this methodological objective marks the culmination of a promising branch of biological experimentation which is century-old in its inception. The method is a resultant of the efforts, first, of the physiologists to develop a satisfactory substitute for the normal life-sustaining environment of the organs, and, second, of the tissue-culturists and bacteriologists to bar life-destroying microorganisms from cultures of living matter.

There can be no doubt that the method provides a powerful instrument for biological investigation. There is no lack of faith or enthusiasm on the part of the authors as to the possibilities of further developments.



SPECTRO-BIOLOGY.

By Maryla de Chrapowicki. C. W. Daniel Co., Ltd., London. 3s. 6d. 8½ x 5; 5 + 62; 1938.

When one is faced with the startling fact that within a 62 page thesis, the author is going to:

(1) Establish a definite proof that light is the only biological factor which controls every aspect of physical existence; (2) Offer a method whereby we can calculate with absolute precision what the normal biological factor of each individual body should be and how to control the structural integrity of a form; (3) Show that health is a purely biological state and a direct result of radiation, while disease is but a relative condition not pathological in itself; (4) Prove that there is a changeless universal method of diagnosis whereby we can not only determine the cause of a disease, but which enables us to preserve a normal state of health in such a perfect equilibrium as to prevent disease and to promote the expansion of an individual life to reach the fullest scope of its physical existence;

one reads eagerly—but alas, he is overtaken by disappointment ere he has finished the first sentence.

The consensus of opinion of the American medical profession concerning light and color therapy has been expressed previously in several journals, and in each

case the proponents of chromo-therapy are considered in the same category with all the other quacks and faddists in the profession. The strain placed upon one's common sense in trying to believe that a person born at 4:30 P.M. on April 14 has only to have his face and head treated to cure him of appendicitis is so great that we are inclined to disagree with the statement of the publisher on the inside front cover that "*Spectro-Biology* will be counted as one of the most important medical books of the year".



INTOXICATIONS ET CARENCE ALIMENTAIRES.

By Maurice Loeper, E. Bioy, J. Cottet, M. Debray, R. Degos, L. Duchon, G. Garçin, E. Gilbrin, A. Lemaire, A. Lesure, G. Marchal, J. L. Parrot, M. Perrault, P. Soulié, R. Turpin and A. Varay. Masson et Cie, Paris. 60 francs. 9½ x 6½; viii + 259; 1938 (paper).

An introductory chapter by Professor Loeper outlines the thesis which he has maintained for some time relative to the causes, signs and treatment of those digestive disturbances which apparently have no organic foundation. The abnormal and excessive reactions of the intestinal and gastric mucosa to generally innocuous foods, manifest in gastric upsets such as pain, flatulence, and diarrhea, are considered by him as a syndrome which he calls digestive hypersensitivity. He notes, in addition, that such hypersensitivity can be demonstrated by a subcutaneous injection test that he has devised. The treatment he advocates consists mainly of dietary precautions. The remaining chapters of this book are the contributions of several students and associates who discuss with relation to this idea the anatomy, physiology and biochemistry of the digestive tract. Each of the articles is characterized by a sound general review of the literature on the subject, but none contains bibliographic references. Loeper's views are interesting but it is obvious that he and his associates have only begun to investigate their implications, some of which may be important for the study of human variability.

ADVENTURES IN RESPIRATION. *Modes of Asphyxiation and Methods of Resuscitation.* By Yandell Henderson. Williams and Wilkins Co., Baltimore. \$3.00. 8½ x 5½; xi + 316; 1938.

There are many who will not agree with some of the author's conclusions regarding asphyxiation and resuscitation but none will deny that this book is fascinating. Here are real adventures into a respiratory jungle where carbon monoxide poisoning, shock, acidosis, mountain sickness are some of the menacing predators that are encountered and battled. Dr. Henderson has his own ideas on how these enemies should be overcome and he is not afraid to voice his opinions, but he is a true scientist and presents both sides of each contention. Since his conclusions are far from being fly-by-night inspirations but based on actual experimentation, and since those which have finally received recognition have proved to be correct (as the use of carbon dioxide in the Henderson-Haldane inhalator), his side of the argument carries much weight.

The book is neatly balanced between technicality to prevent ambiguity, and simplicity to enable a high school student to understand it. All and sundry will find enjoyment and gain knowledge through its perusal.



HIGH BLOOD PRESSURE AND LONGEVITY and Other Essays Selected From the Published Writings of David Riesman.

By David Riesman. John C. Winston Co., Philadelphia. (Not for sale.) 9 x 6; xii + 726; 1938.

Friends and admirers of Professor Riesman on the occasion of his seventieth birthday in 1937 selected some 80 of his papers and have republished them in this volume. The articles deal with a variety of topics in clinical medicine, pathology, and the history of medicine. They have been arranged in sections dealing respectively with reports on diseases of the cardiovascular system, lungs, gastrointestinal tract, nervous system, and endocrines. In order, these are followed by papers on infectious diseases, diagnostic signs, and medical history. The title of this col-

lection derives from a well-known paper published in 1931 in which Riesman discussed the diagnosis and care of hypertensive patients and emphasized that hypertension is compatible with longevity.

It is apparent that a happy choice has been made in selecting the representative writings. On the whole, they bring out Riesman's wide range of interests in the field of clinical medicine and, most of all, the wisdom which has characterized his long and active life as a clinician and teacher.



DAS ZWISCHENHIRN UND DIE REGULATION VON KREISLAUF UND ATMUNG. *Beiträge zur Physiologie des Hirnstammes, Teil II.*

By W. R. Hess. Georg Thieme Verlag, Leipzig. RM. 26. (25 percent discount outside of Germany). 12½ x 8½; [8] + 127; 1938 (paper).

The first part of this monograph was reviewed in these columns, Volume 7, page 490, under the title *Die Methodik der lokalisierten Reizung und Ausschaltung subkortikaler Hirnabschnitte*. This was confined almost exclusively to elaborate descriptions of the operative technique perfected on the brain of the cat with the aim of finding out more about the regulatory mechanism of the respiratory and circulatory systems. The present part describes some further experiments, especially with the stimulation of the thalamic and sub-thalamic regions and gives a discussion of the results. It is illustrated with electrographs and photographs and schematic drawings showing the points of stimulation. A bibliography, an index of illustrations, and subject index are included. An important contribution.



HANDBOOK OF PHYSIOLOGY AND BIOCHEMISTRY. *Thirty-fifth Edition.*

By the late W. D. Halliburton and R. J. S. McDowall. P. Blakiston's Sons and Co., Philadelphia. \$5.50. 8½ x 6; xi + 973; 1938.

The first edition of this text (senior author formerly professor of physiology, University of London, King's College, junior

author now occupying the same chair) appeared in 1848. The original author, William Senhouse Kirkes, of St. Bartholomew's Hospital, was followed by various editors up to 1896 when Professor Halliburton took charge and, in 1898, brought out the fourteenth edition. It is hardly necessary to point out that a book which has survived for ninety years and now appears in its thirty-fifth edition has, in the process of evolution, kept abreast of the times at each emergent stage. With the present edition "Biochemistry" appears on the title page for the first time.



MAJOR ENDOCRINE DISORDERS.

By S. Levy Simpson. *John Bale Medical Publications, London.* 10s. 6d. $7\frac{1}{2} \times 4\frac{3}{4}$; x + 184; 1938.

This small book offers an excellent clinical summary of the endocrinopathies. The subject matter is well organized, and the presentation is concise. The syndromes associated with malfunction of each of the endocrine glands are considered from the point of view of pathology, incidence, clinical picture, diagnosis, course and prognosis, and treatment. There is some theoretical discussion, particularly of the pituitary-adrenal-gonadal complex, but on the whole the material is restricted to facts of immediate clinical significance. A tabulation of some of the hormones on the market today, particularly of the British drug houses, is given in the appendix. There is an adequate index.



THE PITUITARY GLAND. *An Investigation of the Most Recent Advances. Association for Research in Nervous and Mental Disease. Vol. XVII of a Series of Research Publications. Proceedings of the Association, New York, December 28th and 29th, 1936.*

Edited by Walter Timme, Angus M. Frantz and Clarence C. Hare. *Williams and Wilkins Co., Baltimore.* \$10.00. 9×6 ; xxiv + 764; 1938.

This publication contains the Proceedings of the Association for Research in Nervous and Mental Disease at the meeting in New York in December, 1936. The ma-

terial, which consists of 42 separate papers relating to the structure and function of the pituitary gland, is presented in three sections. Sections I and II are concerned respectively with the anatomy and physiology of the gland. Section III, General considerations, is primarily clinical in subject-matter. The book is thus a very comprehensive survey of present-day knowledge of the pituitary. Each chapter is followed by a pertinent list of references. The book is well illustrated and indexed.



ABC OF THE VITAMINS. *A Survey in Charts.*

By Jennie Gregory. Foreword by Walter H. Eddy. *Williams and Wilkins Co., Baltimore.* \$3.00. $11\frac{1}{2} \times 9$; xii + 93; 1938.

In this work the author attempts to bring the scattered, intricate facts concerning the controversial field of vitamins into a coherent whole by the restrained use of carefully constructed graphic diagrams. She presents by this method a history of the work upon vitamins, the results of research upon each of the vitamins, the scientific methods employed and the general relations which exist in the field. Without the sacrifice of scientific accuracy or clarity, the book summarizes in a brief space and interesting manner the fundamental problems and results of vitamin research. This book is symptomatic of the extension into university life of the general evolutionary trend towards complete illiteracy that is so rapidly accelerating among human beings in general, as a result of movies, picture magazines, and similar agencies. Why should a biologist ever learn to read, with Miss Gregory's services at command?



BEAUTY PLUS. *The Smart Woman's Key to Beauty, Health and Charm.*

By Mary MacFadyen. Illustrated by Frank N. Netter. *Emerson Books, New York.* \$1.96. $8\frac{1}{2} \times 5\frac{1}{2}$; 272; 1938.

Besides the many obvious trivialities and hints about sex appeal and personality that help pad out these pages, this simply written book contains a wealth of prac-

tical, if sometimes obvious, hints and common sense information. Among its pages are scattered 66 formulas for beauty aids with the approximate cost of the ingredients and instructions for mixing them. This well-indexed and amusingly illustrated volume not only covers every phase of beauty treatment, but also supplies the reader with home cures for hangovers, constipation, and a variety of other unladylike ailments.



ZEITSCHRIFT FÜR ALTERSFORSCHUNG.
Organ für Erforschung der Physiologie und Pathologie der Erscheinungen des Alterns,
Bd. 1.

Edited by Emil Abderhalden and M. Bürger.
Verlag von Theodor Steinkopff, Dresden and Leipzig. Annual subscription RM. 30.
9½ x 6½; 88; 1938.

This is a new periodical devoted to the publication of research on growing old, predominantly from the physiological and clinical standpoints. In the present issue there are no investigations treating longevity (or other problems concerned with age) in a statistical manner. Most of the articles deal with clinical observations on old age or physiological-chemical changes with ageing.



MATERNAL CARE COMPLICATIONS. *The Principles of Management of Some Serious Complications Arising during the Antepartum, Intrapartum, and Postpartum Periods.* Approved by The American Committee on Maternal Welfare, Inc.

Edited by F. L. Adair. Prepared by R. D. Mussey, P. F. Williams and F. H. Falls.
University of Chicago Press, Chicago.

\$1.00. 7½ x 5½; vii + 95; 1938.

A condensed discussion of the classification, symptoms, treatment and prognosis of toxemias of pregnancy, obstetric hemorrhages, and puerperal infections is presented in this booklet. It is clearly and competently written and in general outlines the conclusions and views accepted by the specialists in the field. There is neither index nor bibliography.

A TEXT-BOOK OF THE DISEASES OF THE SMALL DOMESTIC ANIMALS. *Third Edition, Thoroughly Revised.*

By Oscar V. Brumley. Lea and Febiger, Philadelphia. \$4.75. 7½ x 5½; 597; 1938.

The third edition of this text (2nd. edition reviewed in Q. R. B., Vol. 7, No. 2) for students and guide for the practitioner has been brought up to date, some of the sections being entirely rewritten and others changed to conform to recent advances in knowledge. The section on diseases of the fowl has been eliminated. A detailed index adds much to the book's usefulness.



BIOCHEMISTRY

BIODYNAMICA. *A Scientific Journal for the Elaboration and the Experimental Study of Working Hypotheses on the Nature of Life.* Volume 1.

Edited by Basile J. Luyet. *Biodynamica, Normandy, Mo.* \$6.00 per volume. 9½ x 6½; iv + 392; Numbers 1-2, October, 1934; Numbers 3-8, June, 1935; Numbers 9-15, March, 1936; Numbers 16-24, December, 1936; Numbers 25-28, August, 1937; Numbers 29-32, December, 1937; Number 33, April, 1938. (paper).

Researchers in the physical sciences have used with a great deal of success a method of study beginning with mathematical speculation and ending in experimental verification. Luyet and his associates are following the physicist's method of "working hypotheses" and have founded "Biodynamica" for the publication of papers dealing with working hypotheses on the nature of life and with the experimental study of these hypotheses." The founders of this publication wish to solicit the collaboration of all those interested and will accept papers in any of the languages recognized for scientific publication. Unverifiable speculations will not be printed in *Biodynamica*. Each accepted article is treated as a separate pamphlet with its own issue number and pagination.

Biodynamica is not a periodical publication and is issued only as material develops. Over a period of four years, October, 1934 to April, 1938, a total of

33 papers has been published. Luyet and his collaborators have written about forty-two per cent of the total experimental researches printed over this period of time. In the first issue of *Biodynamica*, Luyet states his *biocondensation* hypothesis "according to which the fundamental living units, which are supposed to be some formed constituents of the cell, especially the chromosomes, possess a particular physical structure in which matter is more concentrated than in the ground substance of the cell, . . .", and if these living units "consist of more concentrated matter, their specific gravity, their conductivity coefficient for heat and electricity, their heat capacity, their co-efficient of transparency for all the radiations—in general, all their physical properties—should be different from the properties of the ground substance of the cell." Also the physical properties of living matter should be different from what they are in dead matter. Following this line of thought, many articles containing alleged experimental verifications of the biocondensation hypothesis have been published.

On *Biodynamica's* cover there are two emblematic figures placed side by side in conjunction with each other. The figure on the left side represents the modern conception of an atom of carbon with a positively charged nucleus and six negative electrons, two in an inner orbit and four in an outer orbit; the symbol on the right represents a mitotic figure, evidently in metaphase. Together the symbols are supposed to express the publication's program, "which is to disclose the inter-relationships between physical chemistry and biology."



INTRODUCTION TO PHYSIOLOGICAL CHEMISTRY. *Fourth Edition.*

By Meyer Bodansky. John Wiley and Sons, New York; Chapman and Hall, London. \$4.00. 9 x 5½; ix + 686; 1938.

LABORATORY MANUAL OF PHYSIOLOGICAL CHEMISTRY. *Fourth Edition.*

By Meyer Bodansky and Marion Fay. John Wiley and Sons, New York; Chapman and Hall, London. \$2.00. 9 x 5½; vii + 295; 1938.

In the present edition of Bodansky's text (for previous review, cf. Q. R. B., Vol. 10, No. 3) additional space has been given such subjects as enzymes, hormones and vitamins. The subjects of digestion and the chemistry of enzymes have been given separate chapters, Dr. Oscar Bodansky having prepared the latter chapter as well as the one on physiological oxidations. Wherever possible "an attempt has been made to include in the discussion sufficient material to enable the reader to gain some appreciation of the continuity of biochemical research and to realize the stages by which the present position has been attained."

Most of the changes in the revision of the manual (third edition noticed in Q. R. B., Vol. 10, No. 3) have been made in an attempt to clarify directions and to render them more workable for the elementary student.



AIDS TO BIOCHEMISTRY. *Second Edition.*

By E. A. Cooper and S. D. Nicholas. William Wood and Co., Baltimore. \$1.50. 6½ x 3½; vii + 213; 1938.

OUTLINES OF BIOCHEMISTRY. *The Organic Chemistry and the Physicochemical Reactions of Biologically Important Compounds and Systems. Second Edition.*

By Ross A. Gortner. John Wiley and Sons, New York; Chapman and Hall, London. \$6.00. 9 x 6; xx + 1017; 1938.

The second edition of *Aids to Biochemistry* (first edition appeared in 1937) has been partly rewritten. Chapters on hormones and hydrogen ion concentration have been added and the chapter on carbohydrates and vitamins extended. The balance between the theoretical and experimental aspects of biochemistry has been maintained so that the student can continue to use the book as a guide in the laboratory as well as for purposes of reading and revision.

The present edition of the second of these books, an excellent text, represents an extensive revision and in many instances a complete rewriting of the text. Additional chapters deal with oxidation-reduction, the flavins, the hormones, and lignin.

AN INTRODUCTION TO BACTERIOLOGICAL CHEMISTRY.

By C. G. Anderson. William Wood and Co., Baltimore. \$4.00. $7\frac{1}{2} \times 4\frac{3}{8}$; viii + 278; 1938.

This book, which the author describes as "a survey of the whole field in a form suitable for students," seems to assume a degree of antecedent knowledge which ought to make a survey unnecessary. The outgrowth of his own series of lectures to advanced students, it covers such topics as: growth factors; nitrogen and carbohydrate metabolism; proteins, polysaccharides, lipoids, and pigments of microorganisms. There is also a section on immunochemistry.

The elementary student ordinarily is satisfied with the chemistry to be found in any good textbook of bacteriology, while the advanced student will probably have more use for the two-volume Buchanan and Fulmer to which the author refers at the ends of many of his chapters. It is difficult for the reviewer to see for whom this book is written.



ANNUAL REVIEW OF BIOCHEMISTRY. Volume VII.

Edited by James M. Luck and Carl R. Noller. *Annual Review of Biochemistry*, Stanford University P. O., Calif. \$5.00. $8\frac{3}{4} \times 6$; ix + 571; 1938.

As usual the contributions (23 in number) in this volume of the *Review* represent a distinguished group of investigators and students, and cover a wide range of subjects in the biochemical field. This year, the review belonging in the group of "Topics of timely nature" is *Organic Insecticides* by F. B. La Forge and L. N. Markwood. To those who are unacquainted with the *Review* attention should be called to the valuable reference lists which accompany each section. In a science which is expanding as rapidly as this one is it is most useful to have the various subjects under discussion so well documented. The volume concludes with excellent author and subject indexes. The Editorial Committee announces the forthcoming publication of the *Annual*

Review of Physiology—a companion volume to the *Annual Review of Biochemistry*. This will be a joint undertaking with the American Physiological Society.



THE CHEMISTRY OF THE STERIDS.

By Harry Sobotka. Williams and Wilkins Co., Baltimore. \$8.50. $8\frac{1}{2} \times 5\frac{1}{2}$; xiii + 634; 1938.

The first sixth of this book outlines the history of sterid chemistry, the chemical and physical properties of the bile acids, other sterids and their molecular compounds, and analytic methods. The major portion (335 pages) is a classified catalog of sterids and their derivatives recorded before January 1, 1937. In addition, the author has provided a 63-page bibliography, with references back to the text, a subject index and 404 formulas. This very useful reference work is a companion volume to the author's *Physiological Chemistry of the Bile*. These volumes carry cross-references to each other, thereby facilitating the correlation between chemical and biological progress for students of biliary secretion and hepatic function.



FORTSCHRITTE DER BIOCHEMIE. III Teil (1931-1938).

By Felix Haurowitz. Verlag von Theodor Steinkopff, Dresden and Leipzig. RM. 9 (paper); RM. 9.75 (cloth). $8\frac{3}{4} \times 6$; xi + 167; 1938.

The earlier parts of this solid and useful work have been noted in these columns—Part I (1914-1924) in Vol. 2, p. 143, and Part II (1924-1931) in Vol. 7, p. 370. The present work covers the progress in animal biochemistry between 1931 and 1938. During this period much important work has been published in practically all the special fields of this subject, particularly on the vitamins, sex hormones, carbohydrates, proteins, and enzymes. Many of the former views and conclusions have had to be changed in accordance with the findings of the recent work included in this volume. Almost 1300 bibliographic

titles are given. Our copy is defective due to the faulty assembling of pages.



KOLLOIDCHEMIE DES PROTOPLASMAS.
Zweite, erweiterte und vollständig umgearbeitete Auflage.

By W. W. Lepeschkin. Verlag von Theodor Steinkopff, Dresden and Leipzig. RM. 18. (paper); RM. 19. (cloth). 8½ x 6; xii + 244; 1938.

Since the appearance of this book ten years ago several textbooks on colloidal chemistry have appeared so that the author has omitted the elementary phases of this subject from the original introductory chapter. Additions to the volume include all the important researches of recent date.



BIOCHEMISTRY FOR MEDICAL, DENTAL AND COLLEGE STUDENTS.

By Benjamin Harrow. W. B. Saunders Co., Philadelphia and London. \$3.75. 9¼ x 6; 383; 1938.

An excellent text on biochemistry designed for use among medical, dental, agricultural, and general college students. At the close of each chapter there is a bibliography relating to the subject matter covered within the chapter. Almost every reference is accompanied by a brief comment on its particular value.



THE CHEMICAL ORGANIZATION OF LIVING MATTER. Second Edition.

By C. F. Krafft, 2510 Q Street, N. W., Washington, D. C. 9 x 6; 27 + [2]; 1938 (paper).

The second edition of this pamphlet differs from the first only in the addition of a supplement of two pages entitled "Elastic deformation of protein chemical structures."



THE UNIVERSITY OF COLORADO STUDIES, Volume 25, Number 3. A Group of Papers from the Department of Chemistry.

University of Colorado, Boulder, Colorado. \$1.00. 10 x 6½; 161-224; 1938 (paper).

SEX

LAWS RELATING TO BIRTH CONTROL IN THE UNITED STATES AND ITS TERRITORIES.

By Seymour L. Linfield. Birth Control Clinical Research Bureau, 17 West 16th Street, New York. 25 cents. 8 x 5½; 61; 1938 (paper).

This pamphlet of the federal and state laws concerning the dissemination of contraceptive literature is published not so much for use by legal authorities, physicians, or pharmacists, as it is for bringing to the general public the need for revision of laws which hamper the development of birth control in our country. The point in emphasis is that even though our courts are reading a liberal interpretation into our laws in order to protect those actively interested in the slogan "Every Child a Wanted Child," progress in birth control cannot be realized until Anthony Comstock's ideas are eradicated from our statute books.



SEX AND SENSE.

By T. W. Pym. Nicholson and Watson, London. 2s. 6d. net. 7¼ x 4½; 128; 1938.

Canon Pym discusses in order marriage, masturbation, homosexuality and winds up this work in an effort to tie it all into a rather vague chapter entitled God. Throughout the book he stresses repeatedly the need for sex education, especially by the clergy, emphasizing the lack of coöperation of the church and the need for courses on sex in theological colleges. He finds illicit relationships occurring today "that simply could not have happened 25 years ago," and blames most of today's immorality on birth control. Broadmindedly, however, he admits that contraception may have its place in marriage and the planning of children. Although not caring for the postponement of the first arrival, Canon Pym believes that even this might have its good points from a scientific angle since: "the parents would become more practised; the calmer attitude of the mother might be better for the unborn child."

ATTAINING MANHOOD. *A Doctor Talks to Boys about Sex.*

By George W. Corner. Harper and Bros., New York. \$1.25. $7\frac{1}{2} \times 4\frac{1}{2}$; xi + 67; 1938.

This little book provides straightforward information for the maturing boy. In about sixty pages Dr. Corner attains his objective, namely to write a book about sex suited to the intelligent boy of high school age. There is none of the sensationalism or sensualism that graces more pretentious volumes, nor are there any boring examples taken from the bees and flowers which are in great favor with those people advocating educational methods of teaching sex. Any parent of a growing boy would do well to supply him with this book. The illustrations are very good.



THE TECHNIQUE OF CONTRACEPTION. *An Outline. Fourth Edition.*

By Eric M. Matsner. Foreword by Frederick C. Holden. National Medical Council on Birth Control, 501 Madison Ave., New York. Complimentary copies can be obtained by physicians by writing to the National Medical Council on Birth Control. 9 x 6; 50; 1938.

A brief summary of methods in the technique of birth control. This edition incorporates all recent developments which the medical profession has accepted as therapeutic measures and public health policies.



BIOMETRY

MATHEMATICAL BIOPHYSICS. *Physicomathematical Foundations of Biology.*

By Nicolas Rashevsky. The University of Chicago Press, Chicago, Illinois. \$4.00. $9\frac{1}{2} \times 6\frac{1}{2}$; xvii + 340; 1938.

This book has for its main objective to lay the foundations of a systematic mathematical biology which will have to biology the same relation that mathematical physics has to physics. The subject is introduced with a consideration of the cell, a hypothetical spherical cell to begin with. The equations to describe the in-

ward and outward diffusion and the necessary conditions for the equilibrium of the system are then outlined and developed. From this, the author proceeds to the examination of situations in which the cell is deformed and the metabolism becomes altered and thus is enabled to arrive at a mathematical expression for cell division. This first part concludes with a tentative formulation of a theory of organic form. In the second part of the book the author discusses problems of physiology and psychology: nervous irritability, excitation, inhibition and conduction, reflex actions, learning and thinking. The solutions advanced for these problems have required great ingenuity and depend much on postulates that for the present cannot be verified experimentally. This, of course, is the main difficulty which is met when one attempts to draw practical consequences from or to make use of the ideas expressed in logical or mathematical theorizing. The same difficulty has been encountered in the application of mathematical rationalizations to problems of economics or population. Often enough it has been found that the general though elegant formulations express only what has been postulated and this must be accepted on faith. It is too early to judge the biological value of the author's work. For the time being it can only serve as an additional source of ideas for more observations and experiments.



LABORATORY MANUAL AND PROBLEMS FOR ELEMENTS OF STATISTICAL METHOD.

By Albert E. Waugh. McGraw-Hill Book Co., New York and London. \$1.50. 9 x 6; x + 171; 1938.

This manual is a useful complement to many of the well-known textbooks on the application of statistical methods and especially for that by the author. In the first section there are a great many of the usual statistical tables as useful time-savers. Many of these are taken from other authors, but some have been computed especially for this manual. For instance, tables A 9 and A 10, concerning conversion from probable error to standard

error and inversely, may save the time of the laboratory worker. "The wise statistician soon learns that there are various methods by which he can reduce the amount of purely arithmetical work." In the other sections the most useful statistical formulae (without mathematical derivation), and many examples and exercises in the application of statistical methods are given.



A STATISTICAL STUDY OF THE RATTLE-SNAKES. V. *Head Dimensions. Occasional Papers of the San Diego Society of Natural History, Number 4, May 31, 1938.*

By Laurence M. Klauber. *San Diego Society of Natural History, San Diego, Calif.* 15 cents, postpaid. $8\frac{3}{8} \times 5\frac{3}{8}$; 53; 1938 (paper).

The author of this paper presents a very thorough statistical study of head and body lengths of some 6000 of the western species of rattlesnakes, and points out the advantages and disadvantages of employing these characters as differential criteria. There is a simple linear relationship between head length and body length within a given species, and this relationship varies enough among certain species to be of practical value in classification. The head length-body length relationship in general, however, varies with age and sex to such an extent that the author believes it should not be used alone, but only in substantiating classification based on other taxonomic criteria.



TABLES OF THE ORDINATES AND PROBABILITY INTEGRAL OF THE DISTRIBUTION OF THE CORRELATION COEFFICIENT IN SMALL SAMPLES.

By F. N. David. *Biometrika Office, University College, London.* 10s. $10\frac{7}{8} \times 8\frac{1}{2}$; xxxviii + [6] + 55 + 2 charts; 1938.

The tables give the ordinates and areas of the curves representing the sampling distribution of the correlation coefficient for differing values of n and any population correlation, ρ . The computation of the tables was suggested by Karl Pearson in 1931, and the book forms a further com-

plement to the well-known *Tables for Statisticians and Biometricians*.



PSYCHOLOGY AND BEHAVIOR

POPULAR PSYCHOLOGICAL FALLACIES.

By James G. Taylor. *C. A. Watts and Co., Ltd., London.* 7s. 6d. net. $8\frac{1}{2} \times 5\frac{1}{2}$; vii + 275; 1938.

This is a collection of essays dealing with different phases of psychology. Each chapter is complete in itself and independent of the others. They are not equally meritorious.

Within the past generation a multitude of new schools of psychological thought have arisen, and since one cannot accept them all an impartial criticism is helpful. Although the only psychologists mentioned by name whose theories have been subjected to such an analytical criticism are William James and Siegmund Freud, the present reviewer is inclined to suspect that Rudolf Eucken was in the back of the mind of the author while writing much of this book.

Among the subjects discussed are laboratory technique (an excellent discussion, by the way), the number of the senses, the relation between the mental and physical universes (rather unhappy, because no convincing conclusions are reached, but it is not fair to condemn the author for failing to arrive at a solution of the mystery that has baffled all the great intellects of history), race prejudice, militaristic propaganda, the Bolshevik purge, the political dictatorships, Buchmanism, and personal conversion. The author's views on these and many other subjects are likely to stimulate the reader's thought, especially if he doesn't agree with them. There is no index.



THE BEHAVIOR OF ORGANISMS. *An Experimental Analysis.*

By B. F. Skinner. *D. Appleton-Century Co., New York and London.* \$5.00. $8\frac{3}{4} \times 6$; ix + 457; 1938.

The behavior of the white rat is here completely analyzed in a quantitative

manner. The rats were placed in uniform cages each of which contained a lever placed within the natural reach of the rodent's paws. Every time the lever was pressed the action was automatically recorded. The records were then collected and studied and the conclusions that were derived were therefore based on data obtained in an objective manner with personal interpretations eliminated.

The term system as applied by the author "consists of an aggregation of related variables, singled out for the sake of convenient investigation and description from all the various phenomena presented by a given subject matter." He then goes on to state that confusion among current systems of behavior is the result of no agreement as to what the principal variables in behavior are, or as to their precise definition. These faults have been corrected.

Although the rat is the exclusive experimental organism treated in this book, its behavior has far reaching implications which may well apply to the behavior of man.



PSYCHOLOGICAL DEVELOPMENT. *An Introduction to Genetic Psychology.*

By Norman L. Munn. Houghton Mifflin Co., Boston. \$3.25. 8½ x 5½; xx + 582; 1938.

Dr. Munn, Professor of Psychology at Vanderbilt University, states in his forward that he has attempted "to sketch the chief trends of racial and individual psychological development in a manner which will make these understandable to undergraduate students of psychology and education." The scope of the material and ideologies which he covers in realizing his objective is so tremendous that he is forced to resort to condensation which the beginning student may find bewildering and the more advanced student superficial. The fundamental viewpoint is biological and the subject matter which terminates in a discussion of human personality changes from adolescence to senescence is, in the beginning, devoted to a presentation of the main facts of cytology, genetics, the phylogenesis of unlearned behavior, and the evolution of

intelligent behavior. The facts of human behavior are then reviewed: prenatal, postnatal, intellectual, emotional, and social. Two chapters are devoted to language functions. The organization of material in chapters and sections and the literary style are in the academic tradition. There is a bibliography of approximately 1000 pertinent references, an index of authors and an index of subject matter.



HUMAN POWERS AND THEIR RELATIONS.

By K. W. Monsarrat. Hodder and Stoughton, Ltd., London. 10s. 6d. 10 x 6½; vii + 289; 1938.

In this, the second volume of a series, Monsarrat continues to develop his philosophy of interpretation of human behavior. The main features of his thesis are (1) man should consider himself and his fellow-beings as "powers" or dynamic entities, (2) societies constitute "power-units" of the same order and variation in their characteristics is determined by differences in organization, (3) the powers and power-units tend continuously to achieve a state of equilibrium and thus human social behavior is stimulated. In this volume an attempt is made to illustrate these concepts with examples taken from physics, chemistry and biology, human and otherwise. Although this may be regarded as a profound work, at least from the standpoint of introspective social psychology, it suffers greatly from prolixity, lack of clarity and a unique terminology. It must also be noted, that stripped of their peculiar verbal expressions, the main ideas are not quite original. One needs only recall, for example, the work of the mathematical economists such as Pareto, Walras and others to find similar concepts.



PSYCHIATRIE MÉDICALE, PHYSIOLOGIQUE ET EXPÉRIMENTALE. *Sémiologie—Thérapeutique.*

By H. Baruk. Masson et Cie, Paris. 220 francs. 9½ x 6½; 827; 1938 (paper). This book by the French psychiatrist Baruk is the result of fifteen years of work, experimental and clinical, in the psychiatric field. The viewpoint, typical of the

French school of psychiatry, is predominantly organic. The subject matter is presented in four parts. Part I is devoted to a discussion of the psychiatric conditions associated with known organic defects (tumors, infection, circulatory disturbances). Catatonia and hysteria, with experimental work related to each, are included in the first part. Part II is concerned with the various clinical phenomena associated with psychoses and psychoneuroses. Chapters are devoted to disturbances of sleep, psychomotor activity, thinking and visceral function. In Part III, the question of treatment is reviewed. In the last part, problems related to the organization and administration of a psychiatric hospital are discussed. There is an excellent bibliography of 628 titles and a subject index.



INTRODUCTION TO METHODS IN EXPERIMENTAL PSYCHOLOGY.

By Miles A. Tinker and Kenneth H. Baker.
D. Appleton-Century Co., New York and London. \$2.75. 10½ x 8½; vii + 222 + 4 plates; 1938.

This manual is designed to meet the needs of instructors who desire to give large classes of beginning students a laboratory training in the basic principles of experimental methods of psychology. It subordinates studies of perception, memory, and psychophysics in order to interest the students in the contemporary problems of learning and personality.

The spiral binding facilitates ease in handling, and the book in general is most efficiently constructed; it includes graph paper, photographs for use in emotional studies, explanatory text material, and a bibliography. Its final value, however, will lie in the ability of the individual instructor to surmount the crystallized and predigested aspects of the work.



INTRODUCTION TO GENERAL PSYCHOLOGY.

By James B. Stroud. Prentice-Hall, Inc., New York. \$3.25. 8 x 5½; xv + 681; 1938.

Dr. Stroud of the Kansas State Teacher's College attempts to present "some of the

basic facts and major explanatory concepts of behavior". Included in this volume's nearly 700 pages are discussions of instinct and culture; personality; sensory, perceptual, and learning processes; and memory and intelligence. The work is amply illustrated with charts of results, diagrams of apparatus and nerve processes, and photographs of outstanding psychologists.

The book is limited by its scanty bibliography of "selected references," its singleness of viewpoint, and its looseness of organization which rambles to a forbidding length as an introductory text. On the other hand, it has not been "popularized".



A LABORATORY MANUAL IN GENERAL EXPERIMENTAL PSYCHOLOGY. Revised Edition.

By Norman L. Munn. Prentice-Hall, Inc., New York. \$1.90. 11 x 9; viii + 286; 1938 (paper).

This manual—devised to acquaint students with the experimental investigation of outstanding current psychological problems—does not represent any particular school of psychology to the exclusion of others. Objectivity is stressed throughout. In the revision those changes which teaching experience has indicated have been made. A useful laboratory guide.

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE MIND OF THE ANCIENT WORLD. A Consideration of Pliny's Natural History.

By H. N. Wethered. Longmans Green and Co., London and New York. \$4.00. 8½ x 5½; xv + 302; 1937.

Pliny's object in writing the *Natural History* was to produce an exhaustive compendium setting forth everything that was known about the natural world. He obtained his material from three sources—his own personal observations, the written record of earlier observers, chiefly Aristotle, and the tales brought home by soldiers and sailors of the Roman legions who had seen service in foreign parts. The information from the first two sources was quite authentic, but unfortunately the soldiers and sailors of that day were

like those of today in that they took such delight in astonishing those who stayed at home with the tales of their adventures.

The entire work is not so much a description of the world as of what Pliny's contemporaries thought about the world. In it Pliny states the superstition (that is still popular today) that a puppy whose tail is bitten off can not go mad, and he speaks of rain-storms of milk, blood, wool, tiles, bricks, frogs, and fish, in all of which he is quite skeptical. His account of the olive trees that marched across the highway to plant themselves in a new locality as an omen of dire events to come in the reign of Nero takes up more space than his discussion of the commercial uses of olive oil, and his discussion of jewels emphasizes their use in quack medicine rather than in the arts.

This is not, however, so much the place to discuss Pliny's work as Mr. Wethered's interpretation of it. Much of it consists of direct quotation, but there is also a great deal of comment on unquoted parts, and these are liberally interspersed with quotations from later writers, to the extent of their indebtedness to the *Natural History*. For instance he believes that Shakespeare's knowledge of animate nature was derived almost entirely from Pliny.

It has been commonly stated that Pliny met his death while making a scientific study of Vesuvius in eruption. An entry in his note book is the basis of this belief. But Pliny the younger tells us that when his uncle arrived at the stricken area he was so impressed by the scenes of devastation that he threw himself wholeheartedly into the task of evacuating the victims of the cataclysm, and while engaged in this work of mercy was overcome by the poisonous fumes from the volcano.

There is an intensely interesting appendix discussing the natural science of the middle ages, and an index of ten pages.



AN ORIENTATION IN SCIENCE. *First Edition.*

By Ten Members of the University of Rochester Faculty. C. W. Watkeys, Editor. H. A. Alling, W. Berry, R. G.

Daggs, F. W. Fairbanks, R. W. Holmkamp, J. E. Hoffmeister, C. Stern, R. P. Titsler, W. E. Van de Walle. McGraw-Hill Book Co., New York and London. \$3.50. 9 x 5½; x + 560; 1938.

This book aims high but strikes low. It consists of a series of chapters each contributed by a different author, apparently written without consultation. Just as a chain can be no stronger than its weakest link, so can the strength of a book be no greater than that of its weakest chapter. In this work the chapter on astronomy contains the statement that absolute motion in space can be detected, and that on physics that the mass of an object, if correctly measured, is constant for all observers. These premises are consistent with the classical physics of Galileo and Newton, and might have passed unchallenged a generation ago, but in the light of modern relativity physics they are no longer tenable. Einstein is mentioned in these chapters, but only in connection with some of his earliest work; there is no mention made of either theory of relativity.

On the other hand, the chapter dealing with mathematics is excellent. The treatment of the process of integration, while painfully brief, is more logical than that in any textbook which has ever come to the attention of the present reviewer. The same thing may be said about the discussions of imaginary quantities, the failure of the commutative law of multiplication in higher mathematics, and the non-Euclidean geometries. Saccheri receives the attention he deserves, but the name of Bolyai is unexpectedly absent.

The chapter dealing with psychology is extremely well written, as is also that on the philosophy of science. The remaining chapters are good, but do not strike fire from the imagination. There is an index of 17 pages.



SCIENCE IN GENERAL EDUCATION. *Suggestions for Science Teachers in Secondary Schools and in the Lower Division of Colleges. Report of the Committee on the Function of Science in General Education.*

Commission of Secondary School Curriculum, Progressive Education Association. D. Appleton-Century Co., New York. \$3.00. 8½ x 5½; xiii + 591; 1937.

This report constitutes one of a series of publications to result from the Commission on Secondary School Curriculum appointed by the Progressive Education Association. In the first part of the book the purpose of education and the particular methods of teaching science in a democracy are considered. The main ideas developed here are borrowed from the writings of Dewey and his school. Emphasis is placed on developing children with distinctive personality, allowing the free play of intelligence, and fostering co-operation. Moreover, the teacher should give particular attention to the matter of social sensitivity, tolerance, and reflective thinking in the students. The second part discusses the methods of teaching science in relation to problems of health and disease, development of personality and ideas, sex and family behavior, social and economic principles. In the last two parts of this book, more and specific instructions are given relative to the individual personality problems of the children and a definite program is outlined. In substance then, it is proposed to teach particularly some of the practical aspects of scientific knowledge and to satisfy the immediate curiosity of the student rather than to try to make him understand the fundamentals of the ordered body of knowledge about a certain subject. There is much to be said in favor of such views although some objections could also be raised. In the first place, an attempt is made to use science as the justification of a particular political philosophy. This is always bad for science no matter how worthy is the ideal. In the second place, teachers able to execute such a program to the letter and actually increase the knowledge of the students must certainly be few in number because a tremendous store of learning is necessary to give an accurate and informative answer even to such a simple question as that regarding bread-making, for example, if one is to bring out its sociological, economic, biological, chemical and physical aspects.

A PHILOSOPHY FOR A MODERN MAN.

By H. Levy. Victor Gollancz, London. 7s. 6d. net. 7½ x 5; 287; 1938.

This is an entertaining book dealing with a kind of practical philosophy. The laws of nature are first discussed from a general statistical point of view; then the changes in history and social developments in modern times. Practical questions are always placed in the foreground. In an introductory chapter the author characterizes his standpoint as follows:

If a philosophy does not illuminate the practice of ordinary life, we maintain it fails in its function. It must be something drawn from the world of human affairs and guiding it. To lead a philosophy in this way from the barren wilderness of speculation into the rough and tumble of action is more than to violate the traditional meaning of philosophy.

Accordingly, some elementary assumptions are made in the beginning to illustrate the further philosophical development: (1) The universe exists; this we state as a truism that we shall not question. If it does not exist, its problems disappear with it. Those who question this need not proceed further with this book, the author says. The other assumptions are: (2) The universe is a changing entity; (3) Language is the liaison officer between the physical world about us, the actions, feelings, and thoughts about that world that flow within us, and the interpretation we pass on to each other; (4) Detailed changes show themselves within relatively permanent groups or collections; and (5) The universe contains also human beings with a changing consciousness of the material world about them, changing thoughts, feelings, perceptions and actions. The book will probably find many interested readers.



IN THE SPIRIT OF WILLIAM JAMES.

By Ralph B. Perry. Yale University Press, New Haven. \$2.00. 8 x 5½; xii + 211; 1938.

This volume consists of the Powell lectures delivered at Indiana University and of some of the material already published in the author's Pulitzer prize work on

William James. The personality of this philosopher is presented to the reader as a contrast to that of Royce who like his friend James is also one of the great exponents of American philosophy. James, as the author describes him in the first chapter, was a cosmopolitan, a man socially minded, of ardent convictions and receptive to new ideas. His philosophical ideas are summarized in the following chapters which discuss his empirical theory of knowledge, the metaphysics surrounding it, and his liberalism manifest in theory and practice. One of the striking features of this presentation is the author's sympathetic interpretation of James's views and the strenuous efforts made to give his philosophy a consistency it admittedly lacks. Particularly pathetic appear the author's endeavors to answer definitively, in the light of his own and James's ideas, the question of when the liberal should use force in promoting liberalism. Although this book is primarily of interest to the philosopher it, as well as James's work, could and should be read by those dedicated to scientific studies. In particular, it would be well to keep in mind one of James's principles that in the search for truth all methods of approach are equally valid *a priori*.



ENCYCLOPEDIA AND UNIFIED SCIENCE. *International Encyclopedia of Unified Science. Volumes I and II: Foundations of the Unity of Science, Volume I, Number 1.* Containing the following articles: *Unified Science as Encyclopedic Integration*, by Otto Neurath; *Analysis and Synthesis in Science*, by Niels Bohr; *Unity of Science as a Social Problem*, by John Dewey; *On the Importance of Logical Form*, by Bertrand Russell; *Logical Foundations of the Unity of Science*, by Rudolf Carnap; *Scientific Empiricism*, by Charles W. Morris.

University of Chicago Press, Chicago. \$1.00. 9½ x 6½; viii + 75; 1938 (paper).
FOUNDATIONS OF THE THEORY OF SIGNS. *International Encyclopedia of Unified Science, Volumes I and II: Foundations of the Unity of Science, Volume I, Number 2.*

By Charles W. Morris. University of Chicago Press, Chicago. \$1.00. 9½ x 6½; vii + 59; 1938 (paper).

PROCEDURES OF EMPIRICAL SCIENCE. *International Encyclopedia of Unified Science. Volume 1, Number 5.*

By Victor F. Lenzen. University of Chicago Press, Chicago. \$1.00. 9½ x 6½; vii + 59; 1938 (paper).

The *International Encyclopedia* is the seedling of a series of recent annual conferences devoted to the amalgamation of all branches of science. The first two volumes are being published as a background for the 1939 meeting and as an introduction to the volumes to follow. Otto Neurath explains in the first number that "The Encyclopedia is to be constructed like an onion" with this as the "heart". Other short articles enlarge upon the editor's introduction. John Dewey writes of the social aspects of scientific unity, while Bertrand Russell and Rudolf Carnap speak of logical form and terminology. But less like an onion heart than like an artichoke, most of these articles necessitate peeling off a lot of verbiage before one can get at the digestible portion.

The second number is a highly theoretical treatise designed to unify scientists in their diverse points of view concerning signs. Mr. Morris describes semiotic which is a panacea for scientific ailments, and particularly for our horrid language tangle, so sadly in need of "debabilization". The reader is run through the gauntlet of syntactics, semantics, and pragmatics, with their dimensions of semiosis and linguistic structures. And so the added babel of sign theory may make its contribution to scientific simplification.

"The problem of empirical science is the acquisition and systematization of knowledge concerning the things and phenomena experienced in observation." Mr. Lenzen expands on this at some length, discussing perception, measurement, and classification, both macrophysical and microphysical. The ideas contained therein are commonly known to scientific people. The final pages contain a good evaluation of the prospects for unity of science. This unity lies in the similarity of experimental procedure, although no single limited set of principles can be applied to all branches of science.



PROFILES IN HUMAN BIOLOGY. I AND II

By RICHARD RICHARDSON

[*Editorial Note:* It is ever the aim of the *QUARTERLY REVIEW OF BIOLOGY* to entertain as well as inform its clients. When we learned of the existence of the verses that will be included in the present series steps were taken at once to secure the exclusive rights to disseminate them to the eagerly waiting world of biologists. The expense was enormous, but service is our watchword.

The author of these *Profiles*, more of which may be expected to follow in later issues, is an American biologist of great distinction, who prefers to use a *nom de plume* in the present connection, for reasons that may become even more obvious as the series continues. Prosodically speaking Richard Richardson prefers free verse, of the shortest of short meter type. But in his case the form is not of first importance, for the same thing can justly be said of his writing that Edmund Clarence Stedman once said of Walter Savage Landor's—"His prose, though strictly prosaic in form . . . is more imaginative than other men's verses."

The breadth and variety of Professor Richardson's academic experience, instructional, investigative, and administrative, guarantee the soundness and penetrating quality of the observations about the various types of university fauna embodied in the *Profiles*. A worldly wisdom as vagarious as it is vagissatory will make itself evident as the series unfolds. *βραχεὺς λόγῳ καὶ πολλὰ πρόκειται σοφά*].

I

THE PEDAGOGUE

HE STALKS about our Land
Teaching young things to teach
What they do not know.
He has all the solemn dignity
Of a funeral director
And usually a leonine
Head of iron-gray hair.
He flocks to conventions,
"Panel discussions"
And conferences.
To him gregariousness

Is more stimulating
Than alcohol.
His speeches usually begin
With the trials of his youth
And end
With a plea for more taxes.
(If he knew Latin
He would intone:
"Ita missa est.")
Anyone who takes the trouble
To teach himself
Is "underprivileged."
(How does he think learning
Came into this world?)
Still—
I probably do the crew an injustice,
For I understand there are several
Who have read a book.
But, on the whole:
"They'll none of 'em be missed—
They'll none of 'em be missed."

II

THE ECONOMIST

BEHOLD the Economist,
Who is "cock-sure that every-
thing
Is up to him,
And he is up to everything."
He is industrious
And computes
Elaborate indices
To the fifth decimal place—
Including the current price of zebras
In the Zoo

And the last scanty remnant
Of the modern bathing suit.

Yet his is a science
Based upon a single sin.
Why did he choose Avarice
When so many other deadly sins
Are more pleasant?
Probably because
It begins with the first letter
Of the Alphabet.
He is sceptical
Of the Mystery of the Trinity,
But is faithful unto death
To the Mystery of the Currency.

He has yet to explain a medieval cathedral,
A Rodin

Or an Icelandic saga.
But that's all right!
He has never heard of them.
For his concepts of history
Are curious.
He is forever
Confusing
Adam Smith
With Adam.

Some day
We shall erect
A monument
In his honor.
But perhaps it will be kinder
To leave
The inscription plate
Blank.



THE QUARTERLY REVIEW *of* BIOLOGY



SOCIAL DOMINANCE AND SEXUAL STATUS IN THE CHIMPANZEE

By ROBERT M. YERKES

Yale Laboratories of Primate Biology

IN THE spring of 1938 I conducted a survey of the adult and adolescent population of the Yale chimpanzee colony at Orange Park, Florida, to test the ability of the animals to respond appropriately to a visual situation after delay and change in the spatial relations of the stimulus objects. My primary interest was in the discovery of the representational process which is basic to the development of any form of language. Previously, in working with young chimpanzees, we had observed that in the absence of the spatial factor delayed response is extremely difficult (Yerkes and Yerkes, 1928; Nissen *et al.*, 1938). It seemed possible that representational processes might be more common or more highly developed in the adult than in the immature ape. Therefore this investigation, which is part of a systematic attempt to discover the pre-human fundament of linguistic process and to trace the phylogenesis of language in the Order Primates.

For this inquiry the simplest experimental situation practicable was sought (cf. Fig. 1). Two rectangular wooden

food-boxes, the one white, the other black, each with a convenient handle and a hinged lid, served as stimulus objects. The subject, confined in its living cage behind walls of wire netting, 2-inch mesh, was allowed to watch the experimenter place a piece of apple in the box on the animal's right and before it. This might be either the white or the black box. Then, behind a screen, the two boxes were shifted in relation to one another and immediately presented before the cage, about 50 cm. apart, in such manner that the subject might indicate its choice by opening the box in which it expected to find the apple. The animals were neither isolated nor placed in a special observational cage, but instead were used just as they happened to be located, which was mostly in associated pairs.

In what follows we shall consider not the evidences bearing on representational process and response, but instead a by-product of the experiment, to wit: certain variations in the social behavior of pairs of subjects and the discovery of correlated or causal psychobiological factors. For,

as it happened, it was my good fortune to present to my subjects an experimental situation which served admirably to exhibit a major pattern of social relationship, together with at least some of its essential conditions. This cannot better be made clear to the reader than by describing examples of fluctuating social relationship which early in the investiga-

whenever opportunity offered. Nana was definitely subordinated to Wendy's desires and usually would not approach the cage panel before which the boxes were presented until Wendy had completed her trials and left the front of the cage.

For days Wendy had been consistently dominant; Nana, unprotestingly subordinate. Then, suddenly, on May 21st,



FIG. 1. WHITE AND BLACK FOOD BOXES ON CONVEYOR BEFORE ANIMAL CAGE
In the background appears the opaque screen behind which the boxes were shifted in relative position.

tion thrust themselves upon my attention and stirred my curiosity.

SOME ILLUSTRATIVE OBSERVATIONS

The multiparous females Wendy and Nana (see Table 1), each with a nursing baby about four months old, constituted one of my pairs of subjects. They were entirely friendly, old acquaintances. In the experiment Wendy initially assumed priority of response and took the lead

a new pattern of behavior appeared. Wendy came as usual when the boxes were presented, but instead of choosing between them she tried to raise the lids of both boxes simultaneously, and when prevented she refused to respond and allowed Nana to take her place. This behavior was so at variance with what had gone before, and the change was so abrupt, that I was surprised and puzzled. It was as if an idea which she wished to try out in the

experimental situation had occurred to Wendy. Interestingly enough, she continued wholly good-natured, patient, calm, eager for the apple, and friendly toward both cage companion and experimenter.

The experiment was necessarily omitted May 22d, and when on the 23d Wendy was again given opportunity to respond to the boxes she hesitated, delayed, and finally let Nana come between her and the boxes and open one of them. Whereas previously it had looked as though she were testing the value of a new method of problem solution, it now appeared that she wished, or at least was willing, to give first place to Nana. And in fact it became clear on subsequent days that the dominance-subordination relation had been reversed, for Wendy continued to yield priority of response to Nana and in varied ways accorded her privilege.

As Wendy's behavior inevitably stimulated my curiosity, I turned in my search for an explanation to the results with other pairs of subjects and discovered analogous variations in the dominance relationship.

Thus the congenial multiparous females Pati and Dita, who for years had been intimates, exhibited fluctuation in priority and privilege. During the early days of my experiment Pati asserted leadership and Dita calmly took second place. The social relationship was at once definite and predictable. A variation in this pattern of behavior appeared on May 23d. When I came to their cage to test them, Pati and Dita were lying together on the floor engaged in what appeared to be sexual play. Called to come for the experiment, Pati unwontedly delayed. After a few seconds she arose and started toward me, but Dita clung to one of her legs and she broke away slowly and with evident reluctance. Finally Pati came

and began to make response. Her second trial was incorrect, but instead of complaining or screaming in resentment, as ordinarily would have happened, she quietly gave Dita opportunity to take her place. Contrary to my previous observations, Dita at once hastened to the front of the cage and there responded freely, correctly, and as if by right. Pati offered no objection, and while thus yielding privilege to Dita she was calm, gentle, and good-natured. Dita, as if fully realizing the change in her social status, acted as though it were her natural right to take precedence of her companion. This fluctuation in social relationship is no less surprising than that exhibited by Wendy and Nana. But, before explanation is sought, yet another instance of reversal of dominance will be presented.

This time it is between mates. The mature male Bokar and the mature but nulliparous female Bentia constituted a pair of experimental subjects. From the first Bokar assumed priority of response, and so strong was his dominance over the female that as a rule she would not venture to come to the boxes when he was near. Because of this I finally gave up trying to experiment with her, and for several days I worked with Bokar only. On May 21st, as I prepared to present the boxes, Bentia offered herself sexually to Bokar and was accepted. Immediately after the completion of copulation, she took her place beside him in readiness to respond to the boxes. Bokar made no protest. Surprised by the new pattern of social behavior, I decided at once to test the male's patience, so when he raised the lid of the food-containing box I handed the apple to Bentia instead of to him. She took it as if by right, and he patiently awaited his next trial. Each subject completed its series of trials as if on terms of equality with the other.

On succeeding days, although Bokar rarely delayed sufficiently to permit Bentia to take first place in the experiment, she, after presenting sexually and being accepted, seemed to have perfect confidence in his gentleness and good nature, and would crowd in beside or even in front of him and attempt to open one of the boxes and secure the apple. If not actually dominant, she had in any event achieved a degree of privilege which precludes use of the term subordination. Evidently Bokar's dominance either was markedly lessened or temporarily in abeyance.

These three instances of marked variation in the dominance relationship appeared almost simultaneously in the delayed response experiment. As a matter of course I immediately sought some common factor in subject or environmental situation which might serve as explanation. Examination of my observational data revealed the sexual swelling in one of the subjects as a condition common to all cases. And since neither in the experimental situation itself nor in the environmental circumstances was I able to discover any common factor which could be correlated with the change in pattern of social behavior, I proceeded with further inquiry into the significance of changing sexual status. The following facts are pertinent.

It will be recalled that Wendy and Nana were lactating females with babies. Ordinarily, under these circumstances, the chimpanzee neither menstruates nor exhibits periodic genital swelling. During the period of my experiment, Wendy showed no obvious fluctuation of sexual status and there was no evidence of cyclical swelling. But Nana, on the contrary, on May 22d, following two days of tumescence of the genital area, was recorded as in maximal swelling. It was at this time that Wendy's relation to her, as

exhibited by my experiment, changed abruptly and Nana became leader instead of follower. One may suspect that the social privilege so abruptly accorded Nana resulted from Wendy's response to the immediate sexual phase of her companion. When her genital swelling subsided, Nana again became definitely subordinate to Wendy.

As for Pati and Dita, both were mature, non-pregnant females, subject to recurrent five-week sexual cycles. Both had been nursing infants until about six weeks prior to my observations. Dita's infant was taken from her March 28th and Pati's on March 30th. In neither did sexual swelling occur during the period of lactation, or between the weaning of the infant and the beginning of my experiment. In my period of experimentation Dita exhibited neither menstruation nor marked genital swelling, whereas Pati, after five days of tumescence, achieved maximal swelling on May 21st. It was at this time, and only during the swelling phase of her cycle, that her dominance over Dita weakened and she granted her varied privileges. Under these circumstances Dita tended to assume toward her sexually receptive companion the rôle of male in their homosexual behavior. At no time did Pati yield priority of response to Dita; she merely permitted her certain social liberties and freedom of initiative. This occurred only during Pati's brief period of maximal sexual excitability and receptivity.

The case of Bokar and Bentia is subject to the same hypothetical explanation. Bentia menstruated April 29th; from May 11th to 17th she was recorded as tumescent, and on the 18th as in maximal swelling. It was on the 21st that in the experimental situation I observed her to offer herself sexually to her mate and immediately thereafter to claim and receive privilege. This modification of the

social behavior pattern continued as long as the female was in the phase of genital swelling. Prior to this phase Bokar had ignored Bentia sexually. After the swelling disappeared and Bentia was again sexually non-receptive, the male became indifferent to her, resumed his former dominance, and on a few days, while awaiting the presentation of the boxes, masturbated by rubbing against the cage floor. Bentia, at this time markedly subordinate to her mate, was extremely cautious and timid in the experiment, as if fearful of antagonizing and provoking him to violence. So long as she was sexually acceptable to the male, this female could, and at times quite clearly did, exchange sexual coöperation for the privilege of working on equal terms with her mate in my experiment.

Common to the three cases which have been selected for detailed and illustrative description because of their diversity and simultaneity of appearance, is the fact that pronounced alteration in the social behavior pattern of dominance-subordination occurred during the phase of maximal genital swelling. It should be remarked as a significant fact, which is well established by observations in these laboratories, that the female chimpanzee is sexually receptive and acceptable to the male only during this phase of the sexual cycle, or for a limited portion of it. It further appears that the period of greatest sexual excitability, or oestrus, occurs toward the end of maximal swelling (Yerkes and Elder, 1936).

PRIMATE DOMINANCE AND MASCULINITY

Before we consider further the results of this investigation, I should like to present certain facts, assumptions, and questions relative to primate dominance and sex.

As a conspicuous feature of behavior,

dominance has long been known in many types of primate, whereas recognition of its social significance and useful accounts of its characteristics and relations are recent. Zuckerman (1932) definitely established its importance as principle of social organization in the baboon; Carpenter (1934) revealed its virtual absence in the howler monkey, and the frequent occurrence of communistic behavior; and Maslow (1936), after demonstrating its occurrence in several genera of primates, states: "We need feel no hesitation about concluding that dominance is an extremely important determiner of social and sexual behavior in the monkey" (p. 275).

Although thus far it has not been adequately described, the dominance relationship appears frequently in the social behavior of the chimpanzee. I have long found it convenient to use in my records of observation the expression "dominance-subordination" (Yerkes, 1925, p. 155). A working definition is in point. In the present report, dominance implies simply priority of response and ability to delay or inhibit the response of a companion. This, however, is not an adequate descriptive definition of the phenomenon, for the dominant chimpanzee generally assumes also the right to satisfy any or all needs, desires, or whims before permitting a companion to do likewise. Less predictable is the assumption of leadership and initiative in safeguarding social welfare.

Dominance has come to be associated with masculinity, and subordination with femininity, in mammalian behavior. The validity of this association for the chimpanzee may be questioned, since dominance behavior is exhibited by females as well as males and seems to be linked rather with temperament and physique than with sex characters. Moreover, it has not been proved that in the naturally dominant

female the trait is less strongly developed than in the comparable male. For these reasons it is likely to prove far more profitable to seek the facts relative to the nature and relations of dominance-subordination in chimpanzees than to accept what may turn out to be myth or misinformation.

In lieu of adequate information, the following questions may aid us in our efforts to evaluate and interpret the observational materials of this report. Presumably the queries are as applicable to the behavior of man as of chimpanzee.

1. Are the assemblages of psychobiological traits to which the terms masculinity and femininity are applied determined primarily by heredity or by social environment? Have we perhaps tended to ignore or underestimate the influence of culture versus genes in the development of those behavioral patterns which appear to differentiate the sexes? Manifestly certain structures and functions of male and female are hereditary. Is it not equally clear that hormones and individual experience tend throughout life to establish or modify sex traits (Terman and Miles, 1936)?

2. Should either or both masculinity-femininity and dominance-subordination be described as continua, that is, single series of psychobiological values, or are they instead, as certain authorities assume, discrete psychobiological entities, each with constituent parts and relations which do not appear in the other?

3. Are dominance and subordination, which in this connection I assume to designate two different behavioral patterns, demonstrably hereditary?

4. And, if the answer to the above be affirmative, are they sex-limited, or is every individual irrespective of sex by nature either dominant or subordinate, and does its rôle in a given social situation

depend on previous experience and the immediate circumstances? The latter question is pertinent because it is definitely established for the primates that the same individual may be dominant at one time, subordinate at another.

In formulating these questions I have had constantly in mind psychobiological instead of morphological sex characteristics.

Current knowledge and understanding of the sexual behavior of primates from monkey to man are entirely inadequate for present theoretical and practical needs, by reason chiefly of their incompleteness and inaccuracy. By comparison with problems of "learning," relatively little attention has been given by psychobiologists to inquiry into the problems of sex. Especially valuable in their many bearings on the observations and conclusions of this report are the pioneer exploratory studies of the sexual life of monkeys and baboons by Hamilton (1914) and Kempf (1917), and the painstaking description of the development of sexual behavior in the young chimpanzee by Bingham (1928). Hamilton and Kempf, both psychopathologists, with therapeutic interests and concern about the validity of psychoanalytic findings, assumptions, and interpretations, made signally important discoveries and suggestions. The adult patterns of chimpanzee sexual behavior which are of special importance to us in this study may be described by reference, since we have already published from these laboratories accounts which go far toward completing the genetic inquiry so well begun by Bingham. In the following reports much information relative to sexual behavior and its relations may be found: Tinklepaugh (1933, 1933a), Yerkes and Elder (1936), Yerkes (1939).

For readers who are not familiar with the principal features of the chimpanzee

sexual cycle, the following description may be serviceable. The duration of the cycle is approximately five weeks (Elder and Yerkes, 1936). Its externally observable phases number six: the menstrual, postmenstrual, tumescent (during which the tissues about the vagina and anus swell), maximal swelling, detumescent, and premenstrual. At its maximum the genital swelling usually is very conspicuous, and throughout the cycle changes in the color, tension, and volume of the genital area are readily observable. Therefore, it is relatively easy to follow the course of a cycle by daily observation and to date important events. For this, among other reasons, the female chimpanzee is eminently serviceable in various studies of sex and reproduction. According to our present data, ovulation in this primate occurs some fourteen days before the beginning of the next menstrual cycle and at or near the termination of maximal genital swelling (Elder, 1938).

THE OBSERVATIONAL SITUATION AND PROCEDURES

The environmental setting of this inquiry was eminently suitable for experimental work on problems of behavior, but even more important, for success in this particular investigation, was the nature of the chimpanzee subjects. All males (three) were mature and experienced as mates; all females were either sexually mature (fifteen) or in late adolescence (four). These apes had been in use in the laboratory-colony for three to thirteen years. For each a record was available in the laboratory files, which included the developmental, sexual, reproductive, disease, and experimental histories. In the case of adolescent and mature females, daily observation of sexual and reproductive status was a part of the record. Chronological age either was known by

date of birth or estimated from reasonably adequate growth norms and knowledge of the developmental history and growth vicissitudes of the individual. Almost without exception these animals were known to the observer with respect to psychobiological traits and social relations. Such information, it should be unnecessary to remark, is indispensable if behavioral observations are to be correctly interpreted and advantageously used for comparisons. Without it efforts to describe sexual behavior and to determine the relations of sexual status to such phenomena as those of dominance and subordination are futile.

The subjects are listed, with essential items of information, in Table 1. Members of experimental pairs appear in the horizontal lines, the dominant individual at the left, the subordinate at the right. For descriptive convenience and easy reference, the pairs have been arranged in four categories, which are based upon sex and reproductive status: (1) mates, (2) mature females, (3) mature and immature females, and (4) immature females. Except as indicated, all subjects are female. The only immature individuals are so indicated, either by the abbreviation "Im." following the name or by the classificatory category.

The experimental situation offered the pair of subjects immediate opportunity to respond to the presentation of concealed food and to compete, in accordance with their natural and acquired social-response tendencies, in trying to secure it. To be sure, the food-seeking response was made amidst certain uncontrolled variables in the environment: the activities of other members of the colony, of men about the buildings, meteorological conditions, not to mention variables from day to day in the psychobiological condition and affective relations of the subjects themselves.

Observations were made during May to July, 1938. The study of non-positional delayed response had been in progress somewhat more than a fortnight before I realized that other interesting responses

sociology experimental! Immediately I designed a record form to enable me quickly to describe what appeared to be important features of social response which were exhibited in my experiment.

TABLE 1
Pairs of subjects

| DOMINANT | | | SUBORDINATE | | | NO. OF OBS. |
|-----------------------------|---------------|------------------|-------------|---------------|------------------|-------------|
| Name | Age 1/1/38 | Weight 6/1/38 | Name | Age 1/1/38 | Weight 6/1/38 | |
| Mates | | | | | | |
| | Yrs. | Kg. | | Yrs. | Kg. | |
| Bokar ♂ | 13 | 47.2 | Bentia | 12 | 33.5 | 21 |
| Jack ♂ | 18 | 51.9 | Josie | 16 | 41.2 | 5 |
| Mona | 25 | 66.0 | Jack ♂ | 18 | 51.9 | 29 |
| Pan ♂ | 16 | 46.9 | Mamo | 9½ | 39.3 | 1 |
| Pan ♂ | 16 | 46.9 | Mona | 25 | 66.0 | 5 |
| Pan ♂ | 16 | 46.9 | Pati | 18 | 48.6 | 27 |
| Pati | 18 | 48.6 | Bokar ♂ | 13 | 47.2 | 1 |
| Mature females | | | | | | |
| | | | | | | |
| Dita | 18 | 41.6 | Fifi | 20 | 37.8 | 13 |
| Josie | 16 | 41.2 | Soda | 10½ | 37.4 | 13 |
| Lia | 14 | 40.7 | Josie | 16 | 41.2 | 16 |
| May | 13 | 40.0 | Dita | 18 | 41.6 | 13 |
| Mimi | 15 | 48.9 | Fifi | 20 | 37.8 | 21 |
| Mimi | 15 | 48.9 | May | 13 | 40.0 | 13 |
| Nira | 12 | 40.7 | Cuba | 12 | 40.5 | 34 |
| Pati | 18 | 48.6 | Dita | 18 | 41.6 | 6 |
| Soda | 10½ | 37.4 | Mamo | 9½ | 39.3 | 20 |
| Wendy | 15 | 45.0* | Nana | 17 | 41.0* | 16 |
| Mature and immature females | | | | | | |
| | | | | | | |
| Lia | 14 | 40.7 | Alpha (Im.) | 7 | 39.0 | 3 |
| Bentia | 12 | 33.5 | Bula (Im.) | 7½ | 31.6 | 4 |
| Mamo | 9½ | 39.3 | Lita (Im.) | 8 | 32.8 | 13 |
| Immature females | | | | | | |
| | | | | | | |
| Alpha | 7 | 39.0 | Lita | 8 | 32.8 | 21 |
| Bimba | 8½ | 33.6 | Bula | 7½ | 31.6 | 22 |

* Weight with nursing infant.

than those I was recording were appearing, and that in neglecting them I might miss an excellent opportunity to discover facts and principles of chimpanzee social behavior, and incidentally to help make

This record form, as appears from the sample series of observations in Table 2, provides for the entry of the names of subjects, date, sexual status, dominance or subordination response, priority of

TABLE 2
Dominance-subordination observations for the mares Mona and Jack

| SUBJECTS AND DATE | SEXUAL STATUS* | DOM. OR SUB. | 1ST OR 2D | RE-SPONDED | RIGHT OR PRIVILEGE | REMARKS ABOUT BEHAVIOR |
|-------------------|----------------------|--------------|-----------|------------|--------------------|------------------------------|
| Mona | Max g.s. | D | 1 | Yes | Right | Came to gate panel |
| June 4 | — | S | 2 | Yes | Privilege | Responded on wall at side |
| Jack | | | | | | |
| Mona | Max g.s. | S-D | 2 | Yes | Rt.—Priv. | Yielded privilege to Jack |
| June 5 | — | D-S | 1 | Yes | Right | Reversal of relation |
| Jack | | | | | | Came to gate panel |
| Mona | — $\frac{1}{2}$ g.s. | D | 2 | Yes | Right | Begging, impatient, militant |
| June 6 | — | S | 1 | Yes | Privilege | Calm, patient, yielding |
| Jack | | | | | | |
| Mona | — $\frac{3}{4}$ g.s. | D | 1 | Yes | Right | Impatient and irritable |
| June 7 | — | S | 2 | Yes | Privilege | Calm, discreet, yielding |
| Jack | | | | | | |
| Mona | — $\frac{1}{2}$ g.s. | D-S | 1 | Yes | Right | Came to gate panel |
| June 8 | — | S-D | 2 | Yes | Privilege | They worked side by side |
| Jack | | | | | | Came to gate panel |
| Mona | — $\frac{1}{2}$ g.s. | Equality | 1 | Yes | Right | Impatient when incorrect |
| June 9 | — | | 2 | Yes | Right | Both responded at gate |
| Jack | | | | | | Calm, fearless, assertive |
| Mona | P.R. | D-S | 1 | Yes | Rt.—Priv. | No interference with Jack |
| June 10 | — | S-D | 2 | Yes | Rt.—Priv. | Calm and assured |
| Jack | | | | | | |
| Mona | P.R. | S | 2 | Yes | Right | Calm |
| June 11 | — | D | 1 | Yes | Right | Reversal of relation |
| Jack | | | | | | Impatient, vocalized |
| Mona | P.R. | D-S | 2 | Yes | Right | Impatient |
| June 12 | — | S-D | 1 | Yes | Right | Both responded at gate |
| Jack | | | | | | Calm and fearless |
| Mona | P.R. | S-D | 2 | Yes | Right | Murmurs of protest |
| June 13 | — | D-S | 1 | Yes | Right | Calm, assured |
| Jack | | | | | | |
| Mona | P.R. | S-D | 2 | Yes | Rt.—Priv. | Somewhat impatient |
| June 14 | — | D-S | 1 | Yes | Right | Calm, assured |
| Jack | | | | | | |
| Mona | P.R. | S | 2 | Yes | Privilege | Did not come to gate |
| June 15 | — | D | 1 | Yes | Right | Calm, in control |
| Jack | | | | | | |

* Meaning of symbols for female sexual status: Max g.s. = maximal genital swelling; — $\frac{1}{2}$ g.s. = lessening of genital swelling (detumescence) by $\frac{1}{2}$; P.R. = permanent residual condition of the genito-anal area.

response (1st or 2d), presence or absence of response, whether response was made by right or privilege, and, finally, outstanding features of individual attitude and behavior.

There were two serious limitations of experimentation. In certain instances, it was impracticable to continue the testing of mates throughout a sexual cycle because of the risk of undesired impregnation; and, in others, the requirements of the experiment conflicted with concurrent investigations which we could not afford to sacrifice. Twenty-two pairs of animals were used. In two, only a single dominance-subordination test was made; with the other twenty pairs, the number of observations (see Table 1) ranged from three to thirty-four. These numbers include only observations recorded on the special form which is represented in Table 2. For most of the pairs of subjects a variable number of observations preceded the use of this record form. Whereas the number and variety of pairs were entirely adequate, the number of observations per pair in many cases is undesirably small. Therefore it is excusable to remark, first, that the observer had as background of knowledge for the present undertaking intimate acquaintance with chimpanzee behavior, individual and social; and, second, the serviceable information and insights gained in a study of mating behavior, during which hundreds of controlled matings have been observed. Certainly the observational data of my immediate inquiry would be wholly inadequate as basis for the descriptive statements, generalizations, hypotheses, tentative conclusions, and problem-formulations which appear in this report had I been unfamiliar with the individual subjects and also with outstanding features of primate social behavior and relations. The above are intended as statements of

fact, not as defense or apology, for this is merely a preliminary report concerning an inquiry which, however well begun, has as yet supplied definitive answers to few of the questions which have been, or will be, suggested.

RESULTS OF EXPERIMENT

Under the four categories proposed in Table 1 we shall now examine the results of my experiment to discover the characteristics, variations, and relations of dominance-subordination behavior. The abbreviations "d-s" and "s.s." will occasionally be used to designate dominance-subordination and sexual status.

1. *The behavior of mates.* The male Bokar was dominant over Bentia except when she exhibited genital swelling, at which time he granted her privilege even to the extent of working side by side with him and taking his food. When paired with the female Pati during her sexual swelling, he was dominated by her. Unfortunately opportunity lacked to determine whether the d-s relationship would change, as happened with Bokar and Bentia, when these subjects became sexually indifferent to one another.

Jack, paired with Josie, was definitely dominant over her. He yielded privilege to her during genital swelling, but reversal of d-s was not observed. By contrast, the pairing of Jack and Mona exhibited the dominance of the female while in genital swelling, whereas at other times the male controlled the social situation. However, Mona yielded first place to her mate reluctantly and with many vocal and gestural protests. Additional information about the behavior of this pair appears in Table 2.

Pan, a vasectomized male, seemingly in full sexual vigor and known to be extraordinarily self-assertive and aggressive, wholly dominated the female Mamo when

she was in maximal swelling. She presented sexually and was accepted by the male, but, unlike Bentia, she neither assumed nor achieved privilege in connection with the sexual relation and did not dare to come to the gate panel to respond. Possibly had this relatively young and inexperienced female had the courage to assume right or privilege of response, the male might have granted it, for at no time was he markedly aggressive or rough in his behavior toward her.

With the large and reproductively aged female Mona, Pan was consistently dominant, and although he yielded her privilege and was much more considerate and attentive during the genital-swelling phase, he at no time permitted her to assume priority of response, as she frequently was able to do when paired with Jack. This is the more interesting and significant because Jack, although less courageous than Pan, is of much larger frame and at times has weighed 10 kilograms more.

On the other hand, with the naturally dominant and aggressive female Pati, Pan, although at times of sexual indifference dominant over her, ordinarily accorded her priority of response and the right to do as she liked during the genital-swelling phase. The term "right" is here used advisedly, since her behavior clearly expressed right as contrasted with privilege. So marked was the d-s reversal for these mates that Pan on certain days responded slowly and with caution, as if by privilege rather than right.

For the sake of brevity I must now have recourse to general statements in supplementation of these descriptions of the social behavior of pairs and individuals. The following appear as trends or principles of d-s behavior in relation to s.s.

Ordinarily in a pair of mates, the male, if dominant, yields privilege or right to

the sexually acceptable female during her period of genital swelling and sexual receptivity. Temporary reversal of the d-s relation may occur. When the genital swelling disappears and the female becomes non-receptive, she is also unacceptable sexually to the male and he again becomes dominant. The female of the pair may use sexual response to achieve privilege. This is exemplified in the behavior of Bentia and Bokar.

If in the pair of mates the female happens to be the naturally dominant individual, she may yield privilege or right to the subordinate male for the period of

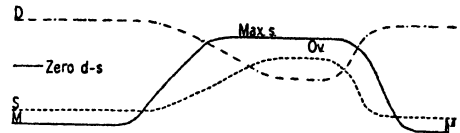


FIG. 2. DIAGRAMMATIC REPRESENTATION OF THE RELATION OF DOMINANCE-SUBORDINATION TO FEMALE SEXUAL STATUS

The solid line (—), beginning and ending with M, menstrual bleeding, indicates the status of genital swelling from the non-tumescent residual condition immediately after and before M to its maximum at Max. s.; Ov, time of ovulation; the broken line (---) represents the strength of dominance or subordination response of the dominant mate, D; the dotted line (·····) that of the subordinate mate, S, in the different phases of the sexual cycle.

her genital swelling, and the d-s relation may during that time be reversed.

The accompanying diagram, Fig. 2, is an attempt to represent the variations of d-s in their relation to phases of the sexual cycle, as observed in the pair Bokar and Bentia, and, less definitely and completely, in pairs Jack and Josie and Pan and Pati.

2. *The behavior of mature females.* Ten pairs of females, of whom all except Nira had been pregnant or borne young, were observed. Although Wendy and Nana, whose behavior has already been described briefly, belong in this category, they are not comparable with the other pairs because of the presence of nursing

infants. For them the social situation was much more complicated than for the other pairs, since four individuals were concerned in the social responses. It will be recalled that the dominant Wendy yielded priority of response to subordinate Nana when the latter exhibited non-menstrual genital swelling. The change in their social relationship gained expression in other behavioral patterns in addition to those of d-s.

The case of Pati and Dita, as already described, revealed that Pati, a strongly dominant individual, when sexually receptive would occasionally grant masculine privilege to her companion Dita. She did so, however, grudgingly, and reversal of d-s never appeared.

For the remaining eight pairs of reproductively mature and experienced females, variety of behavioral pattern is far more impressive than uniformity. Nevertheless, certain behavioral trends and principles are evident.

Dita and Fifi, spirited, aggressive individuals of long acquaintance, struggled continuously for priority. Although smaller and physically inferior (weights: Fifi, 38 kg.; Dita, 42 kg.), Fifi, by courageous and determined self-assertiveness, was able at times to command first place. Her gain in privilege or control parallels her entrance into the genital-swelling phase. Especially notable is the daily fluctuation of d-s relation in this pair. Neither could confidently assume dominance, for commonly it was challenged by the companion.

May and Dita, as pair, are exceptional in that May, the younger and smaller individual, was dominant. When May entered the genital-swelling phase, Dita became unresponsive and refused to work in my experiment. This is puzzling. It may have appeared as reaction to her companion's sexual condition.

In the pair Josie and Soda, the former was decisively dominant. There is some evidence that slight privilege was accorded Soda while in genital swelling.

Lia and Josie, of whom the smaller, Lia, was consistently dominant, were in identical sexual phases during the period of my experiment, and it consequently was impossible to discover the relation of d-s to s-s. The results, however, indicate that when Lia entered the phase of detumescence she tended to yield privilege increasingly to Josie.

Soda and Mamo grew up together in intimacy of acquaintance. The former was the older; the latter, the heavier. Soda assumed dominance. When Mamo exhibited genital swelling, Soda occasionally took the rôle of male. A description of her behavior is essential. She seated herself behind Mamo in the position sometimes taken by a male, pressed her abdomen against Mamo's genital swelling, and made movements which simulated pelvic thrusts. The rhythm of the thrusts was much slower than is usual in the copulating male. It was not observed that Mamo solicited this attention by her companion, and it was my impression that Soda took the initiative. Certainly Soda took the part of the male perfectly, and Mamo as perfectly coöperated with her. Just before the final trial in my experimental series of June 6th, Mamo presented sexually to Soda and again the latter assumed the male position. In this behavior Mamo responded as subordinate female with privilege, whereas Soda obviously played the part of the gentle and considerate male seeking sexual favor.

Mimi and Fifi represented contrasts, for the former was much the larger and Fifi the more courageous and determined. Mimi naturally assumed right of priority and attempted to dominate her com-

panion, while Fifi persistently, and sometimes with success, disputed this right. Indeed, she never yielded completely to Mimi, and from day to day conflict persisted. Between May 24th and June 15th, the period of observation, several fluctuations and one reversal of d-s relation were noted. The relation of d-s to s.s. was obscured by the fact that the sexual cycles were nearly parallel.

Mimi and May also represented mass (Mimi, 49 kg.; May, 40 kg.) as against courage and self-assertiveness. Unfortunately the sexual cycles were nearly contemporaneous. Mimi assumed dominance and May fought against subordination. Although she never succeeded in gaining first place in the experiment, she continued to fret and complain, seldom risking combat with her larger companion. The d-s relation, although not actually in flux, was constantly jeopardized by May's refusal to accept subordination.

Nira and Cuba differed slightly in size. The former was dominant. The d-s relation varied appreciably in strength with the s.s. of the individuals, but without reversal. On June 14th, with Nira in maximal genital swelling and probably also in oestrus, and Cuba in menstrual phase, the dominance of the former and the subordination of the latter were decidedly weaker than usual. Cuba was markedly more confident and venturesome. Taking the rôle of male she backed up to Nira and rubbed her genitalia against Nira's swelling. This pattern of homosexual behavior differs strikingly from that previously described for Soda and Mamo. Nira at this time was coöperative, gentle, friendly, and entirely passive. Once on this date Cuba came to the gate panel—which she rarely had the courage to do because of the risk of provoking attack by her dominant companion—but evidently feeling unsafe she looked toward

Nira inquiringly as she prepared to respond to the boxes.

From the results for these several pairs of mature females it is evident that d-s may remain in flux over a considerable period, varying in strength, direction, or both, with daily incident and accident; that it is influenced in varying degrees by the s.s. of the female companions; and, finally, that the direction of change in d-s relation corresponding to change in the phase of s.s. may not be stated simply and dogmatically, since it apparently varies with pairs and individuals. However, ordinarily the dominant female, as is true of the dominant male between mates, tends to grant d-s privilege, even to the reversal of relationship, when the subordinate female companion is in genital swelling, whereas if she is in this phase of the sexual cycle herself she may encourage or permit her subordinate companion to act as male. Either the dominant or the subordinate female may assume the rôle of male toward the sexually receptive companion.

These facts have been established. The d-s relationship of female companions varies with their sexual status. Homosexual behavior may occur, and at times it may simulate the heterosexual pattern. It is especially worthy of remark, and also of further inquiry, that whereas in many of the other mammals (e.g., cow, sow, guinea pig) when two or more females constitute a social group, the individual in oestrus mounts the companion, in the chimpanzee the female in oestrus instead is mounted or rubbed against by a companion who acts as male.

3. *The behavior of mixed pairs—mature and immature.* It is pertinent to inquire how s.s. is related to d-s patterns in pairs of females only one member of which is mature and capable of exhibiting the several phases of the sexual cycle, and in

which therefore the s.s. influence must be uni-directional. The exhibits are limited to three cases.

Lia and Alpha showed reversal of d-s entirely independently of s.s., for initially Alpha assumed dominance, perhaps because of recency of association with individuals who accepted her as dominant, or, more likely, because of her natural aggressiveness and the fact that Lia was introduced into Alpha's cage. The social scene shortly changed, for Lia asserted herself and in physical combat quickly robbed Alpha of dominance. Protesting vigorously, the latter accepted subordination. Lia was the older as well as the reproductively mature and experienced member of the pair, and she was also slightly heavier, although in appearance she seemed smaller than Alpha.

The case of Bentia and Bula offers points of exceptional interest. Bentia, the mature and experienced individual and the larger, instead of initially asserting herself as naturally dominant, generously allowed Bula to work beside her in the experiment. When Bula in her proper turn took food from an experiment box, Bentia sometimes would beg for it vocally, gesturally, or even by sexual presentation and the rubbing of genitalia. On occasion Bula might respond to such sexual advance in the rôle of male. Although the male position was taken, there were no pelvic thrusts. At the time of these observations Bentia exhibited a small genital swelling. She was not in oestrus. Recalling the previously described relationship of Bentia with the male Bokar, it may be wondered whether her homosexual behavior with Bula was determined by her experience with Bokar, or whether it would have occurred independently of heterosexual experience. Subsequently Bentia became markedly dominant over Bula. This appears to be

a clear case of relationship between d-s and s.s.

In the pair Mamo and Lita—the former mature, experienced, and in genital swelling during my period of observation; the latter, a volatile adolescent—reversal of d-s occurred. At first Mamo gave Lita priority, but on the second day of experimentation, and thereafter, she became dominant. The case is important as exhibiting approach to d-s balance between an unusually aggressive, pugnacious, mature female and a rather flighty and timid adolescent female. The privilege which Mamo initially granted Lita may be attributed to the fact that the former was in an advanced stage of tumescence and presumably sexually receptive.

From the observation of these three cases of mixed pairs it may be stated that in the association of mature with immature individuals the older and more experienced female tends to dominate, and also to initiate sexual behavior, in connection with which she may on occasion subordinate herself temporarily to her sexually immature companion.

4. *The behavior of immature females.* Only two pairs find a place in this category: Alpha with Lita and Bimba with Bula. In each pair the heavier member dominated. No one of the four individuals had exhibited a menstrual cycle. Sexual behavior was not observed during my experiment. The d-s relation was definite and relatively constant for each pair. No reversals were observed. This contrasts strikingly with the fluctuations of d-s relation as exhibited by pairs of mature females.

The following observations relative to sex differences in behavior seem important. In the experimental situation the dominant member of a pair is likely to be restless, impatient, irritable, or even violent, while its companion is working. This be-

havior is more often exhibited by female than by male. The latter exhibits better self-control, ordinarily, and gives place to the subordinate companion with better grace.

The behavior of paired females in the experiment depends on several variable factors, of which sexual status is one. The influence of the latter frequently is obscured by events in daily life which influence affective relations. Examples are: disagreement or contest over food, shelter, possessions. Dominance-subordination may change independently of sexual status, in conjunction therewith, or, it appears, primarily because of the sexual receptivity of a female.

So much has been said about the association of might with right, or, in our immediate terminology, of size with dominance, that it would seem inexcusable to neglect the evidences in this experiment. Does either assure chimpanzee (or man) of the other?

The observational data of weight and dominance, upon which the following statements are based, may be found in Table 1. Among 22 pairs of subjects the heavier member was dominant in 17, the lighter in 5. In the 7 pairings of mates, the male was dominant in 5 cases, the heavier individual also in 5; and in the 15 pairings of females, the heavier individual was dominant in 12.

It is granted without argument that weight is an inadequate measure of either actual or apparent bodily size. Possibly the more dominant a chimpanzee feels and acts, the larger it looks to its companions! The weight averages for the group are misleading because of the small number of cases and the inclusion of an exceptionally heavy female in each group. With this interpretative suggestion and warning, the pertinent statistics are presented.

Average weight in kilograms for pairs

(17) in which the heavier member was dominant: for the dominant individual, 44.8 (A.D. 5.7); for the subordinate individual, 38.6 (A.D. 4.0). If from this group the exceptionally large individual Mona and her mate Jack be omitted, the averages become: dominant individual, 43.5 (A.D. 4.8); subordinate individual, 37.8 (A.D. 3.4).

Average weight for pairs (5) in which the lighter member was dominant: for the dominant individual, 42.4 (A.D. 3.6); for the subordinate individual, 47.3 (A.D. 8.0). Or, omitting the pair in which Mona appeared (Pan-Mona), the averages become: dominant, 41.3 (A.D. 2.9); subordinate, 42.7 (A.D. 3.0).

Physique, as inclusive of weight, apparent and actual size, strength, vigor, and endurance, obviously is positively correlated with dominance, but so also is psychobiological constitution, as determined by heredity and experience and including intellectual as well as affective traits. I have given physique first place because of the statistical balance in its favor, but it is my impression, from acquaintance with my subjects, that their psychobiological traits are more important in shaping their social rôle and relations than are traits of physique. Courage, the assurance of manner characteristic of self-confidence, persistence, and the unquestioning expectation of dominance expressed in bodily posture and attitude, are as obviously determiners of patterns of social relation in chimpanzee as in man.

The observational data which have been presented should not be accepted as adequate basis for definite descriptions of patterns of social relation and change. From them, principles are deducible, but in many instances they cannot be convincingly grounded on fact and must stand as suggestions to be used in problem formulation. Several pairs of subjects supplied

clear-cut, readily interpretable results, but the remainder, because of the several limitations of the inquiry, exhibited instead varieties of d-s pattern, factors affecting or correlated with such patterns, and evidence of the importance of sexual status, which are difficult to evaluate. The results make clear the desirability of observing expressions of social relation in several pairs of individuals, under reasonably constant or comparable conditions, through a number of sexual cycles.

SEX, DOMINANCE, AND PERSONALITY

The chimpanzee is an open book, from which, according to our technical preparedness, patience, skills, and insights, we may read the characteristics, relations, and functional significance of sexual and reproductive behavior. For in it the social taboos, personal inhibitions, superstitions, modesty, shyness, and self-consciousness which render the objective and trustworthy study of human sexual behavior extremely difficult or impossible, are relatively inconspicuous. Relatively I say, because in some degree most of them appear as barriers even in the study of the anthropoid ape. Nevertheless, chimpanzees are incomparably more favorable than are we for the investigation of many psychobiological problems of sex and reproduction.

Obviously, correct and adequate descriptions of the principal patterns and relationships of sexual behavior are essential in connection with inquiry into the rôle of sex in social life. For ourselves, knowledge, although extensive, is difficult to evaluate, whereas for the chimpanzee useful descriptions either are available or may be obtained without great difficulty. Therefore, I submit that such observational items as appear in this report, and in related studies of the psychobiology of sex in the anthropoid apes, should have excep-

tional value for those who concern themselves with problems of social behavior, and, especially at this juncture, for those psychopathologists who are intent on appraising, perfecting, and using psychoanalytical method of observation and interpretation. Currently available knowledge of the sexual behavior of chimpanzees, and in particular that which I have gained in the present investigation and from a study of the patterns and characteristics of mating behavior, constitutes the factual basis for what follows and stands as my sole excuse for writing these paragraphs on anthropoid versus human personality.

In the chimpanzee, personality stands revealed less definitely than in man, but nevertheless very clearly, as the unit of social organization. I have chosen the term personality as preferable to self and individuality and as inclusive of constituents of the id, ego, and superego. It has the psychological and sociological implications which I wish to convey. I use the term to designate the product of the integration of all the psychobiological traits and capacities of the organism. In chimpanzee, as in man, it appears as a functional whole, whose importance for the understanding of social phenomena is incomparably greater than that attaching to the differentia of species, sex, and either structural or functional individuality. In the smoothly functioning, normal, socially effective personality, the basic organic needs or hungers of the natural self are integrated with the hereditary and acquired characteristics of the conscious self. The necessary integrative processes include at least the following as significant elements: forms of inhibition and reinforcement, supplementation, subordination, substitution, and coordination. Personality imbalance due to under- or over-emphasis of essential constituents, as

exemplified in timidity, gluttony, avariciousness, sexual frigidity, or lasciviousness, tends in ape and man to be prejudicial to or destructive of social values.

It is desirable to discover the rôle and relative importance of sexual phenomena in the social life of the chimpanzee. Do they constitute the core or nucleus of anthropoid personality, as Freudian psychopathologists believe to be the case in man, or are they instead merely one among many highly important factor-assemblages in a very complex functional whole? What, in this connection, is indicated by our observations?

The answer may not be stated dogmatically, for evidently we know only in part. I should put the matter thus. Several biological requirements—needs, appetites, desires, interests—in addition to those of sex are evidenced by chimpanzee behavior. Among them are such needs as the nutritive, protective, defensive, developmental (exercise, play), social (companionship, mutual aid), exploratory, inventive, constructive (Yerkes, 1933). These are examples from a long list. There are times when sexual interest and activity overshadow all others in the life of the ape, but frequently, and for long intervals, they remain inconspicuous or in abeyance. At such times the organism may be described as sexually neutral or indifferent. The personality is the while controlled or dominated by other hungers. If one follows the daily life of the ape, it is discovered that non-sexual activities occupy all but a very small fraction of the time. There is no adequate reason to assume that the rôle of sexual function outweighs either the nutritive or the non-sexually social. The fact should here be faced that human interest has tended unduly to magnify sexual behavior in other animals as well as in man himself. This may be attributable in considerable measure to

the psychoanalyst's preoccupation with clinical cases.

Indicated also by my observations, and with clarity and force, is the fact that the rôle of sex differs markedly in male and female, and that chimpanzee personality, whatever may prove to be true of our own, can be adequately described only in terms of masculinity and femininity. The fact is exemplified by the foregoing exhibits of the characteristics of dominance-subordination behavior in their relations to sexual status and activity. Although otherwise the male and female personalities may be very similar, certainly in the nature and expressions of sexual interest and their part in the life of individual and species the sexes are as different as give and take, act or wait, command or obey, right and privilege. In making this statement I am not overlooking the fact that either sex in chimpanzee, as in man, may on occasion be dominant. The fact that in size and strength the adult male ape usually is superior to the adult female determines, or at least favors, a type of social organization—the patriarchal family—in which the female tends to be subordinated to the male even though by nature she may be a dominant individual.

Lest the reader too readily assume that knowledge of the social-sexual life of the chimpanzee can have no values for man other than the satisfaction of his curiosity, since ape and man are so utterly dissimilar, I invite attention to significant likenesses. Notable are the facts relative to characteristics of the structurally determined (hereditary) patterns of sex behavior, the rôle of experience in the perfecting of these basic patterns, the occurrence of affective social attachments and of such varieties of maladjustment as masturbation, rape, and prostitution. There is grave disparity between fact and prevalent opinion.

From a widely read and opinion-molding book by the eminent anthropologist Malinowski, I quote relative to the presumptively sharp contrasts between the sexual life of anthropoid ape and of man:

Let us compare the chain of linked instinctive responses which in animals constitute courtship, marriage and family with the corresponding human institutions. Let us, point after point, go over each link in the love-making and family life of anthropoid apes and ascertain what in human beings corresponds to each.

Among apes the courtship begins with a change in the female organism, determined by physiological factors and automatically releasing the sexual response in the male. The male then proceeds to court according to the selective type of wooing which prevails in a given species. In this all the individuals who are within the range of influence take part, because they are irresistibly attracted by the condition of the female. Rut provides opportunities for display on the part of the males and for selection on the part of the female. All the factors which define animal behaviour at this stage are common to all individuals of the species. They work with such uniformity that for each animal species one set of data and only one has to be given by the zoologist, while, on the other hand, they vary considerably from one species to another, so that for each species a new description is necessary. But within the species the variations, whether individual or otherwise, are so small and irrelevant that the zoologist ignores them and is fully justified in doing so.

Could an anthropologist provide such a formula for the mechanism of courtship and mating in the human species? Obviously not. It is sufficient to open any book referring to the sexual life of humanity, whether it be the classical works of Havelock Ellis, Westermarck, and Frazer or the excellent descriptions in Crawley's *Mystic Rose*, to find that there are innumerable forms of courtship and marriage, that seasons of love-making are different, that types of wooing and winning vary with each culture. To the zoologist the species is the unit, to the anthropologist the unit is the culture. In other words, the zoologist deals with specific instinctive behaviour, the anthropologist with a culturally fashioned habit-response. (1927, pp. 193-194)

At the time of writing, Malinowski's statements relative to the anthropoid apes transcended trustworthy information; today they are contradicted by it. I shall

criticize the quoted statements in the light of knowledge of chimpanzee behavior, omitting mention of the other great apes—gorilla and orang-outan—because they are relatively less well known psychobiologically.

From recorded observations of chimpanzee sexual behavior the following facts and principles appear. The courtship and mating activities and behavioral patterns of individual, pair, or group differ so markedly that they may be used for identificational purposes. In other words, patterns are numerous and diverse; variability is high. True I have no measure of diversity of sexual behavior or of its variability in individual or pair for chimpanzee or any other anthropoid ape, and I doubt that Malinowski has for man. So without apology I oppose my observations to his comparative statements and assert that the contradiction is complete. Further, I hazard the prophecy that when measures of diversity and variability for the sexual behavior of chimpanzee and man are available, the figures for the former will be greater than expected, those for the latter relatively less, and that both sets of measurements will be greater than comparable data for the other mammals. In the last paragraph quoted from Malinowski, it appears that the author assumes the existence of species in anthropoid apes, with diversity of sexual behavior, and accepts the genus *Homo* as a single species. Again observation fails to sustain his contention, for certainly what are recognized as species differences among chimpanzees are neither greater nor more significant functionally than are those exhibited by the so-called races of man.

It is commonly assumed by sociologists, as Miller (1928) has pointed out with disapproval, that in his sexual psychology man differs radically from all other ani-

mals. Our present knowledge would not justify challenge of the assumption were it understood that as between man and anthropoid ape the difference is in degree and proportions, not in kind.

Whereas the sexual life of chimpanzee manifestly is on the instinctive level, and relatively little influenced by such functions as self-consciousness, introspection, representative processes in the shape of memories and imaginings, that of man, although also as natural function structurally determined, is constantly and powerfully influenced by consciousness. The chimpanzee exhibits sexual activity when affected by natural and specific stimuli or stimulus situations, although it is not strictly and narrowly limited to such behavior. While, by contrast, man, under the influence of representational processes, tends constantly to supplement natural stimuli by the creation of imaginary sexual situations. This is the conspicuously important point of contrast between ape and man. In the one, representative process is relatively simple and infrequent, as indicated by the outcome of experimental inquiries; in the other, it is very prevalent. Largely because of this psychobiological difference, mating in chimpanzee tends to be restricted to that period of the sexual cycle near the time of ovulation, when copulatory activity is functionally appropriate, whereas man mates almost irrespective of biological fitness and value for reproduction and often independently also of the biological need, desire, or preference of the female. It is revealed, to be sure, that some men (generic) are nearly animal, some apes nearly human, for instinct survives in man and culture has dawned in chimpanzee. Id and ego-superego functions are reversed in relative importance in these two types of primate, but in neither

of them are the instinctive or the conscious factors lacking.

On a factual basis I have attempted to support the proposition that similarities of ape and man as social organisms are not less conspicuous and significant than are differences. I might add as opinion that it seems stupid of us to neglect or to exaggerate either. Such being the case, it is fitting to suggest that dominance as behavioral trait may be quite as important in our own lives as in that of the chimpanzee. It may not be disputed that in the latter it is an all-pervasive principle of social relationship and of organization, inasmuch as each group tends to be determined and regulated by it.

What I shall say concerning the possible significance of dominance in human life may best be stated hypothetically and with extreme brevity and caution. If in man dominance as personality trait is highly correlated positively with leadership, as it evidently is in chimpanzee; if it is a condition of or markedly favorable to individual initiative, inquiringness, inventiveness, and creativeness; and if, further, it should prove to be reliably measurable during childhood, it may very well come to possess conspicuous values as indicator of vocational aptitudes and social usefulness and therefore also as basis for differential educational treatment and occupational choice. Even marital advice might be affected by it, for congeniality or social fitness may depend appreciably upon similarity or the reverse in dominance as personality trait of mates or companions.

Another possibility suggests itself, which affects primarily the social rôle and status of woman. Assuming that dominance is hereditary and that in inheritance it is independent of sex, men and women might be expected to become creative leaders with approximately equal

frequency. According to statistics, this is not the case in our civilization. It is a natural inference from available data (Terman and Miles, 1936) that our culture is favorable to the development of dominance and to its behavioral expressions in the male and relatively unfavorable to this same development and expression in the female.

I have attempted to suggest problems as well as to state facts. The path to discovery is open and inviting. There is no obvious reason why the informational gaps which have compelled me to substitute hypothetical for factual statements should not speedily be filled. Both ape and man should serve invaluable, according to their peculiarities and availabilities, as experimental subjects.

SUMMARY

When two or more chimpanzees are associated, dominance appears as principle of social relation and a hierarchy is constituted by the dominance order, for every individual tends to be more or less dominant or subordinate to every other.

Dominance implies priority of response; the right or privilege to satisfy all individual needs or desires irrespective of those of companions; and, possibly also, the obligation to exhibit leadership and initiative in the interest of social welfare.

Every individual appears to be by nature either dominant or subordinate. Either sex may be dominant over the other. The larger, older, and more experienced individual ordinarily has advantage.

The dominance-subordination patterns of response are dependent primarily on traits of physique (size, strength, endurance) and of psychobiological constitution (temper, courage, assurance, persistence).

In a simple food-response experiment, the dominance-subordination relation of

twenty-two pairs of adult and adolescent chimpanzees was tested to discover the significance of sexual status. The importance of sexual condition was established.

Dominance-subordination is not a constant relation. It fluctuates or even changes in sign with the sexual status of the female and with such events of daily life as disagreements, contests, or quarrels over food, shelter, possessions, social privilege.

The male if dominant grants privilege to, or is dominated by, the female when she is in oestrus, whereas if subordinate to her he may achieve privilege to the extent of priority of response when she is sexually receptive.

Pairs of mature females exhibit dominance-subordination relationship as do mates. Ordinarily the naturally dominant individual, if in oestrus, grants privilege to her subordinate companion, whereas the subordinate, in oestrus, may achieve privilege and act as if temporarily in control.

In the experiment reported, the dominant member of a pair frequently was restless, impatient, or ill-tempered while waiting for its subordinate companion to take its turn. This emotional response was more common in females than in males. The male is more generous and good-tempered toward a female companion than is another female.

Associated female chimpanzees may exhibit homosexual behavior which closely simulates the heterosexual. But whereas in many other mammals the female in oestrus commonly mounts a companion of like sex, the chimpanzee in these circumstances is mounted.

The mating behavior of chimpanzees may be initiated by either sex, and its form and consummation seem to depend in many cases as much on the one sex

as on the other. The prevalent statement that sexual initiative and control rest with the male is erroneous.

Sexual perversions are exhibited. Examples are: masturbation and hypersexuality by either sex; rape by the male; frigidity and prostitution by the female. The terms are used objectively to designate patterns of behavior and have no reference to purpose or intent.

Chimpanzee sexual life, although greatly modified by experience, is primarily instinctive; that of man, conspicuously imaginative. But clearly neither is nor could be exclusively determined by structure or by experience.

The superior size and strength of the male enhance the opportunity of this sex for the development and exercise of initiative and constructivity.

In turn, the prevalent and characteristic cultural pattern of chimpanzee life (for instance, the patriarchal family group), as presumably has been true also of man, tends to favor the development of capacity for dominance, leadership, originality, and creativeness in the male, and, correspondingly, of subordination, imitative-ness, and conventionality in the female.

Dominance-subordination, as traits of behavior, may turn out to be of far-reaching theoretical and practical significance for social sciences, education, and medicine. The issue rests with discovery of the relation of the traits to sexual processes, leadership, the spirit of inquiry, and constructivity, for any readily measurable trait which is highly correlated

positively with the above should have great diagnostic value.

The chimpanzee is peculiarly valuable for the study of many problems of sex and reproduction, because readily observable changes in the volume, tension, and color of the external genitalia, occurring in the course of the typical five-week sexual cycle, make it possible to date menstruation, oestrus, and ovulation, and also because the social and individual inhibitions, self-consciousness, modesty, and shame, which are barriers in the study of man, are virtually absent in the ape.

It does not appear from the results of this inquiry that the activity of chimpanzee is monopolized by sexual interest. Instead, the sexual appears as one among several biologically essential interests and types of activity.

Are dominance-subordination, as personality traits, positively correlated with the congeniality or compatibility of mates and companions? From the inadequate data at hand, it would appear that opposites in dominance-subordination are better suited to one another than are likes. Has this relationship predictive value in connection with the grouping of chimpanzees, human marriage, or other types of social relationship among primates?

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THE PROBLEM OF CYCLOMORPHOSIS IN DAPHNIA

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THE phenomenon of cyclomorphosis among plankton organisms is particularly well exemplified in fresh-water Cladocera, especially in the group of *Daphnia cucullata* and *D. longispina*. Some changes of form may occur in ontogeny, with age, reproductive condition, or environmental modification; but the cycle of forms is best shown in a sequence of generations, which, following one another at intervals of weeks, may be marked by progressive modifications until the whole population is notably different in appearance from a recently ancestral one. Later the changes occur in reverse order and a complete cycle is made (Fig. 1).

SEASONAL VARIATION IN FORM OF HEAD

Summer generations of *Daphnia* may be so different from winter generations that, before the nature of the phenomenon was made known by Sars (1890) (Fig. 2), Zacharias (1893), and, more particularly, Wesenberg-Lund (1900), the *Daphnias* of one season were assigned not only to different species but sometimes even to different genera. With *Daphnias* the most conspicuous change is in the head, which may be extended to make a great helmet-like feature, turned upward or downward, or directed straight forward, with other differences characteristic for the several races. The forward extension of the head may, in extreme cases, be almost as long as the whole of the remainder of the

body, so that the eye, which was at the front in winter, is near the middle of the body in summer (Fig. 1). Other changes of form occur, but in the following pages we will, for simplicity, restrict attention to form of head, as manifested in helmet development, and, for brevity, speak of round-head *Daphnia* (the winter form) and helmeted or pointed-head *Daphnia* (the summer form).

The changes of form are not simple functions of external conditions or of any inherent cycle, but rather of a combination of internal and external conditions in a way that becomes exceedingly baffling the more we know about it. The environmental conditions involved are the subject of much dispute. The internal conditions, too, are quite unclarified, so that there is discussion of such possible influences as *Präinduction* and position in the "reproductive cycle," or *generation number* (both to be discussed below), with resultant states of *lability*, or degrees of responsiveness.

Heredity, of course, plays its part, but the extent to which heredity governs the particular forms displayed in surprising diversity by the several populations of neighboring waters is not positively known, and there is discussion as to whether heredity may not be actually modifiable by subjection of the race to new environmental conditions for a considerable number of generations. Woltereck (1934, and earlier papers) has adduced

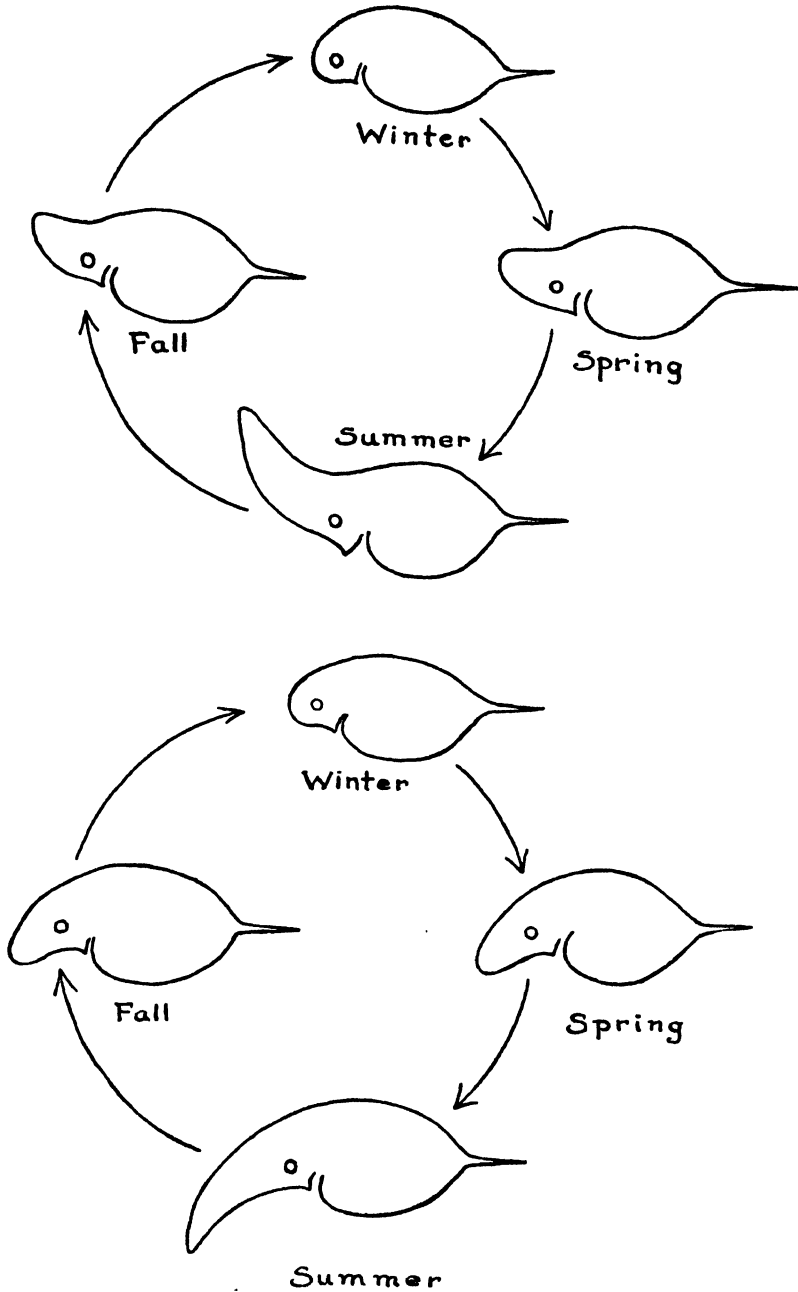


FIG. 1. DIAGRAMMATIC REPRESENTATIONS OF TWO CYCLES, ALIKE IN THE GENERAL COURSE OF EVENTS, AND WITH IDENTICAL WINTER FORMS, BUT CONTRASTING SUMMER FORMS
The cycle need not be quite so simple and regular

evidence that this is the case; he introduced a race of *D. cucullata* from Denmark into a lake in Italy uninhabited by the species and found after a good many generations a changed form which persisted through several generations reared under experimental conditions; the new form was lost by reversion under conditions of *Gegeninduktion*—exposure during several generations to opposing influences. The genetic complex had in his opinion been actually modified during a long period of parthenogenetic reproduction and the modification had persisted for a time, both in the wild and under experimental conditions, but, under the artificial conditions of the laboratory, counter genetic changes were induced in course of a few generations. It would be desirable for conclusions of such significance to genetics and evolution to be checked under conditions of strict control. To many the conclusions stated would seem contrary to the probabilities, but even the well-established facts of cyclomorphosis challenge the probabilities.

The several populations in neighboring bodies of water may undergo synchronous but dissimilar changes. Two lakes in close proximity have *Daphnias* that are apparently identical in winter but very different in summer; one distinguishes them as subspecies, varieties or races, according to one's taxonomic judgment or taste. When compared in January, the two *Daphnias*, although quite indistinguishable morphologically, must be assigned to different varieties because their great-grandchildren will be readily distinguishable. The capacity to form helmets of some particular kind is present but latent during a considerable part of the year, so that the genetic possibilities of the race are realized only at certain seasons. On the other hand, with round-headed *Daphnias* in extreme northern

lakes, where the conditions for cyclomorphosis do not occur, the latency is perennial; apparently there can be no identification to variety or subspecies, and the population must be left in the general residuum of the species. What would happen with such *Daphnias* if one changed the summer conditions by supplying warmth remains to be determined.

Now, cyclomorphosis, with its diversity of summer helmets in different waters, would present a complex enough problem if we had to do in all cases with a winter form and a consistently contrasting summer form. In most cases, indeed, the newborn in late spring have helmets in extreme development and there is little

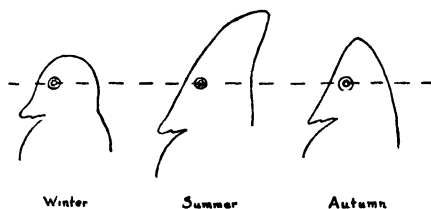


FIG. 2. ILLUSTRATING A VERY MODERATE CYCLOMORPHOSIS OF *HYALODAPHNIA CRISTATA* (NOW *DAPHNIA CUCULLATA* G. O. SARR, SUBSPECIES *CRISTATA*) After Zacharias (1894)

change in ontogeny, but in certain waters, or in certain years perhaps, the cyclomorphic sequence presents its variations. Wesenberg-Lund describes a race in which the young at all seasons are born with round heads while the mature animals show a marked elongation of the head in summer. In another water in Denmark both round and pointed heads occur in winter but the points are high and sharp only in summer. Again he compares two races of *cucullata* from waters less than half a kilometer apart, a lake and a pond with insignificant difference in temperature: in the lake a marked cyclomorphosis extends through the summer; in the pond a dwarf but heavy race begins a cyclo-

morphosis in June and then, in July, the crest diminishes until typical round heads appear in August. In our University Lake near Chapel Hill, N. C., where there are only round heads in winter and sometimes only pointed heads in late spring, we have found some round heads along with the pointed heads in late spring; and, in fall, we have found all round heads one year and a mixed population of round and pointed heads another year. These are merely examples of the diversity of manifestation of cyclomorphosis.

It is well to state here in summary form what seem, from the literature, to be the most clearly established facts regarding the occurrence of cyclomorphosis of Cladocera in nature: (1) A change of form of wild Daphnias, in Danish waters at least, follows a rise in temperature to a point between 12° and 16°C., and a whole population generally responds as one. (2) Once the helmets are fully developed, which occurs in nature within a few weeks in the spring, there is commonly no noticeable further development in later generations with continually rising temperatures; consequently there is only partial correlation between length of helmet and height of temperature. (3) There may occur in autumn a gradual reversion from summer to winter form, or there may be a virtual disappearance of Daphnia in summer (after formation of ehippial eggs?) and a resurgence of exhippial round heads in fall. (4) Helmets once formed are commonly held (in nature) throughout life, although some modification may occur from molt to molt. (5) Increasing richness of food supply is likely to be synchronous in spring with development of helmets, but correlation of length of helmet and abundance of provender is at best only partial and poorly established. (6) The correlation between length of helmets and either temperature or nourish-

ment fails badly when different waters are compared, but what is true of *length* of helmet is not true as regards *time* of first appearance of helmets. (7) There is some correlation, a rough one at least, between size of water (ponds, small lakes, large lakes), and degree of helmet development, whatever that may signify (Gruber, 1923, for *Scapholeberis mucronata*). (8) There occur minor exceptions to the regularity of the sequence of change (see Wesenberg-Lund, 1926; Coker, 1938). (9) Comparing different bodies of water, either remote or neighboring, the general form of the helmet is characteristic for the several populations, although degree of development is variable with time and individual. (Facts regarding the hereditary nature of the multitude of helmet forms are of course derivable only from experiments.)

SOME THEORIES REGARDING HELMETS

It is our habit, and one that might be called almost inveterate, to assume for any phenomenon of organic life that it is adaptive, meaning that it has something to do with the welfare of the organism or that it has survival value. This seems on the face of it to be true of most, but probably not of all, structural or behavioral characters. It is not unnatural, then, that the cyclomorphosis peculiar to plankton organisms should have been the subject of study and of speculation with respect to its utility in the special conditions of life of the plankton. Hence arose the "buoyancy theory" of Wesenberg-Lund (1900): helmets, spines and other processes or protuberances offer resistance to sinking and are therefore more needed in summer, when the water is warmer and lighter than in winter. (The term "floatation processes" is in common use for the bodily extensions in the form of helmets, mucros, spines, setae, etc., but, in view of the ambiguity of the word *process* in Biol-

ogy, I shall, in this paper, employ the less euphonious term "Protuberance." The immediate question is whether the flotation "processes" are concerned in the "process" of floating!) The view of Wesenberg-Lund was soon modified by the "plankton theory" of W. Ostwald (1902, 1904), who followed Wesenberg-Lund in general, but, after a critical study of the seasonal variation of physical conditions of life of the plankton, found the significant variable, as regards velocity of sinking, to be viscosity rather than density. Since viscosity was a function of temperature, he proposed to substitute "temperature polymorphism" for the old term "seasonal polymorphism." The correction as to viscosity in lieu of density, having been accepted by the former author, the Wesenberg-Lund - Ostwald flotation theory won wide acclaim for a time after 1904. It was but a few years, however, before Woltereck (1909, etc.) approached the problem of utility from a different angle and changed, as it were, a problem of statics into one of dynamics.

For Woltereck's masterly analysis of the mechanism of locomotion in several cladoceran species, the interested reader is referred to his paper of 1913. It is too elaborate for adequate summary in a brief space, but the features of his views of special interest in this connection are: (1) that the normal position of *Daphnia* in the water is not such as to make the protuberances effective as organs of flotation; (2) that the Cladocera are active and not passive bodies; and (3) that the protuberances dealt with in studies of cyclomorphosis are not for flotation but are directive and stabilizing surfaces, like rudder and keels of a ship, which serve their functions in guiding the active movement of the animal rather than in keeping it afloat; they aid in maintaining equilibrium and enable the animal to swim in horizontal paths and

thus keep within a relatively thin stratum of water; in brief, it is because of these that the cladoceran does not move in circles or continually turn somersaults forward or backward. The point of application of the propulsive force in locomotion (the base of attachment of the antenna) does not coincide with the center of gravity of the body, but is in advance of it; furthermore, the direction of the effective force of the stroke of the antenna is not parallel to the long axis of the body, but is at an angle thereto and would, therefore, tend to swing the animal about its axis, clockwise or counter-clockwise, according to species, were there no control in the nature of a rudder mechanism. He goes further, holding (4) that it is not the rising temperature or the lowered viscosity that leads to the seasonal changes and gives them survival value; rather it is the better nutrition that promotes the production of the additional body material which takes the form of new or greater outgrowths from the general outline of the body. The outgrowths, having directional value, tend to keep the animals in the stratum of the better food supply that produces the outgrowths. (One may reflect, however, that rudders and keels function only by virtue of the density and viscosity of the medium in which they are used and that viscosity of the water in which the *Daphnia* lives may be only half as great in summer as in winter. "Eddy viscosity" is also a complicating factor in the problem.)

Woltereck holds, too, rather definitely, that the special structures arise in response to need and he sees some sort of direct action of the environment as more effective than individual modifications, which are non-inheritable; than mutations, which occur, but with insignificant effect on cyclomorphosis or on the origin of subspecies; or than *Dauermodifikation* (per-

sistent modification) lasting through only four or five generations and to be discounted as the consequence, originally, of some physiological injury. Most significant is what he conceives as *Differentiation*, referring to collective hereditary alterations that appear in whole populations in response to definite stimuli and are retained in heredity for many generations or until some other collective hereditary alteration serves to undo them. As possibly effective environmental stimuli to induce collective differentiation he depreciates temperature, viscosity and other physical conditions and attaches prime importance generally to nutrition or to something which he rather vaguely terms the *Besonderheit* of the environment (1934).

It has already been intimated that we could not in a brief space expect to do justice to Woltereck's views expressed in a considerable number of long papers over a period of nearly thirty years. Two other features of his theory should, however, be alluded to. Nutrition plus genes is not enough; the capacity of an animal to utilize nutritive substances for the development of extensions of the body depends in great measure upon its place in the reproductive cycle (*generation number*): individuals of the sixth exephippial generation have far greater capacity than those of the second. This is linked with Woltereck's acceptance of the concept of the *reproductive cycles*, first conceived by Weismann, with the corollary concept of "increasing sexuality," a need, progressing from generation to generation, for the change from parthenogenetic to "sexual" reproduction. So much of the experimental evidence of Grosvenor and Smith, Banta and co-workers, Berg and others now relates the changes in mode of reproduction to controllable environmental conditions that the burden of proof of the existence of such a cycle seems clearly to rest upon

those who speak of increasing or decreasing "sexuality" as occurring in cyclic fashion, and who relate cyclomorphic capacity to sexuality in that sense. It is possibly in line with this view that newborn from resting (fertilized) eggs are generally, if not invariably, round heads, as well as females, but some evidence to be adduced later seems not to fit at all into a scheme of graded lability, and there are so many differences between parthenogenetic eggs and resting (ephippial) eggs that the exephippial generation may well be exempt from some of the rules governing any later generation.

Woltereck has also introduced the conception of *Präinduction* for variations which occur as a result of influences exerted on the *germ cells of the developing embryo* in the brood pouch of the mother. Further reference to this is made in connection with the presentation of the results of experiments.

COMMENT ON THE THEORIES

Although our first concern is with the conditions of origin of the helmet, etc., in the individual *Daphnia in vitro* and with the conditions of seasonal origin of helmets in whole populations in the wild, some examination of views concerning the mechanical significance of the structure is, nevertheless, necessary because the question of utility is more or less inevitably involved in consideration of evolutionary origins. Obviously Woltereck's theory involves several practical assumptions: (1) That the best food supply occurs in a relatively narrow stratum in the lakes where cyclomorphosis manifests itself; (2) that the *Daphnias* when in the expanded form keep to a relatively narrow stratum (for which Woltereck adduces much evidence); (3) that the stratum occupied by the helmeted *Daphnia* is the stratum at which the food supply is richest (which Wesen-

berg-Lund, with a wealth of field observational data, does not concede); (4) that development of helmets and reduction of helmets are correlated with increasing and declining food supplies (which is the subject of radical differences of opinion, with much uncertainty as to which side of the balance holds the preponderant weight of evidence); (5) that either the unhelmeted *Daphnias* of winter do swim in circles or that, with the lower metabolic rate of winter, a weaker antennal stroke has less effect in shifting the direction of advance and, therefore, demands less compensative rudder development; (the latter of these alternative assumptions seems plausible, but experimental studies of the locomotion of round-head *Daphnias* in warm water and of helmeted *Daphnias* in cold water would be desirable). Obviously, too, Woltereck's view of the causative influence of nutrition offers no explanation for the fact that, although cyclomorphosis appears in lakes where there is relative poverty of food, it often is not displayed by *Daphnia*, of the same species and of seeming identity in the rounded form, in ponds of apparently the richest nutritive conditions. Similarly, it might be asked with reference to the Wesenberg-Lund-Ostwald theory, and some supporters of the Woltereck view have asked the question: Why do the protuberances not develop in warm shallow ponds as much as they do in cool (but not extremely cold) lakes? The strict adaptationist might well answer either question by saying: That the need for cyclomorphosis does not exist in shallow ponds, however warm and rich in food they may be, for lack of the stratification called for by Woltereck's hypothesis, or for lack of the depth called for by the Wesenberg-Lund-Ostwald hypothesis; that the evolutionary history of the pond race has been different from that of the lake race one hundred yards distant,

because of the different environmental conditions—in the one case there was no necessity to mother the invention of cyclomorphosis, in the other case there was.

Without accepting an adaptational explanation for all structures and features of animals, it may yet be regarded as conceivable and perhaps probable that the cyclomorphic specialties of plankton organisms, both plants and animals, do have in summer positively utilitarian value, *both* as flotation protuberances in the Wesenberg-Lund-Ostwald sense and as directive surfaces in the Woltereck sense. We seem, however, to need additional observations to answer certain specific questions. Among such questions are these: (1) Are unhelmeted *Daphnias* in warm, shallow ponds unable to keep afloat; or, (2) Do they in such waters derive from a relatively rich food supply the greater energy required to keep afloat without helmets? (3) Do *Daphnias* in such ponds lack ability to move in definite planes; or, (4) Do they, for lack of proper food, expend *less* energy in ponds than in lakes, and so have a reduced tendency to steer away from a direct course and correspondingly less need of keels or rudders? Of course such questions are difficult to attack, but, without more facts, generalizations as to the adaptive nature of the helmets and other protuberances remain presumptive. One question underlies all of those just asked: Are the nutritional conditions in ponds better than in lakes, or not? An experimental study might well start from the still more basic question: What specifically are the nutritive conditions necessary to keep a round-head *Daphnia*, as contrasted with a helmeted one, in horizontal paths?

Although the discussion of the adaptive nature of the cyclomorphosis of *Daphnia* includes much that is speculative or at least highly theoretical, the volume of

literature that has developed has brought to light a considerable body of observational evidence which forms an essential part of the background of knowledge and understanding of the reactions that occur in nature and in the laboratory and which are necessary to an ultimate understanding of the phenomena from the points of view of physiology, heredity, and evolution. Nevertheless, there has not as yet been carried out for cyclomorphosis anything like the precise experimental work through which Grosvenor and Smith, Banta and Brown, Berg and others, have so clarified, at least, the problems of sexual and parthenogenetic reproduction in Cladocera. The approach most needed now is through properly controlled experiments to determine the particular stimulus or stimuli to which the animal responds in making the changes of form.

What we have tried to do so far has been: (1) to offer a restatement of the problem, which it has seemed to need, at least in some of its phases, with emphasis on its complexity; (2) to point to the need for more precise experimentation. What we attempt in the following pages is: (1) to summarize the results of our own preliminary experiments dealing with one environmental influence and making, we hope, some contribution to clarification; and (2) to comment on the several angles of interest presented by the problem of cyclomorphosis in Cladocera.

OBSERVATIONS AND EXPERIMENTS

Cyclomorphosis in wild Daphnia

The observations upon *Daphnia* born and bred in nature were made at irregular intervals during a period of several years (1933-1937) in the recently formed University Lake at Chapel Hill, N. C. In Fig. 3 we give a diagram showing the methods used in measuring *Daphnia*. There has not yet been opportunity to

gather all the data required for a detailed record of the cycle. The story, so far as we have it, may be briefly outlined.

In January, every year, all *Daphnias* of the species *longispina* have round heads. In late March or early April round and pointed heads occur in approximately equal proportions, and the distance from center of eye to apex of head relative to the distance from center of eye to base of caudal spine (Fig. 3; Y/X) is nearly 50 per cent greater in the latter (0.144) than in the former (0.10). By early May, 1934, only pointed heads were found and the distance from eye to apex was then relatively twice as great ($Y/X = 0.20$) as in January (0.10). No notable change in proportion occurs during May and June.

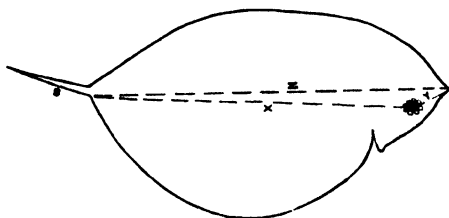


FIG. 3. DIAGRAM SHOWING METHOD OF MEASUREMENT OF DAPHNIA

In July *Daphnia longispina* virtually disappears. In September they reappear, but in October the relative frequencies of round and pointed heads, respectively, is most irregular. Thus on October 1, 1933, when the Lake was still quite new all *Daphnias* had pointed heads; in several collections in the fall of 1934 (September, October, and November) pointed heads occurred but rarely, the great majority being round-headed. On October 6, 1936, and on several dates in September and October, 1937, the conditions were similar to those of 1934. In 1935 only round heads occurred in January, as always; by March 19 about two-thirds of the *Daphnia* were helmeted; so far the story duplicated that of 1934; but, in contrast with the condi-

tions of the preceding year, round heads persisted as long as there were Daphnias in the plankton. In the collection of June 24, for example, 23 per cent of the Daphnias were round-headed. No one environmental or internal influence would seem to offer probable cause of the conditions encountered in the wild population of University Lake.

Data from experiments

Conditions of the experiments

Neither density nor viscosity of medium would seem to be available stimuli for the embryo in the brood pouch except as they might act on the mother and through her on the eggs, but experiments to be mentioned later give evidence that the embryo is not stimulated to cyclomorphic change in this indirect way. "Size of water" and geological age of the water, both mentioned as significant conditions (Gruber, 1923) are not duplicable in the laboratory and can scarcely be conceived to act as stimuli for a particular population at a particular season. Stratification of lakes is seasonal and perhaps to some extent correlated with cyclomorphosis, or both are correlated with temperature, but how stratification can act as a stimulus is not clear. So far no one seems to have recorded a correlation with content of dissolved gases or with light. The significance of the last mentioned is not to be altogether dismissed, although the experiments of McClendon (1910), and our own, in an incidental way, tend to depreciate light as the initial cause of change. We have left, then, as most likely sources of stimuli: heat, light, and the vast array of chemical substances embraced in the broad category of food supply. We have chosen first to test the influence of temperature as the most easily controlled variable among the environmental condi-

tions and as one with which there is clearly a degree of correlation in nature.

Our Daphnia were all reared in individual culture vials, fed with a mixture of small protozoa and green algae, and kept under different conditions of temperature. In the first experiments, the control was only approximate, but in later ones, an apparatus especially designed for the purpose permitted strict and continuous control to a small fraction of a degree (Coker and Constable, 1936). Newborn were always removed from the maternal culture, to be isolated for further observation or discarded. Our particular animal possesses advantage for experimental work in that the helmet or point is unmistakable. When present it may show different degrees of development but determination of the presence or absence requires no measurement, but only observation (compare Fig. 4 with Figs. 5 and 6; see also fig. 7).

Results of the experiments

Observations on many more than 1,000 young bred from mothers in isolation form the basis for these summary statements of results. [Details of observation are given in a larger paper (Coker and Addlestone, 1938).]

(1) At temperatures below 11°C. only round heads were obtained (Fig. 4), at temperatures above 15°C. only pointed heads (Fig. 5). Mixed broods of round and weakly pointed heads (cf. Fig. 6) were obtained at intermediate temperatures in numbers to suggest a critical temperature close to 13°C. Those incubated at 20°C. have more prominent points than those incubated at 16°C. (compare Figs. 3 and 5). Hundreds of experiments in various years with diverse food supplies, conducted generally by myself, but in some cases by students—experiments in which at least a dozen different lines have been used—give no exceptions to the rule as

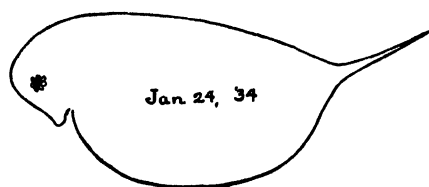


FIG. 4. WINTER FORM OF *DAPHNIA LONGISPINA* IN UNIVERSITY LAKE, CHAPEL HILL, N. C. (JAN. 24, 1934)

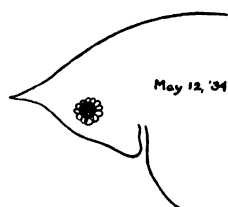


FIG. 5. LATE SPRING FORM OF HEAD OF *DAPHNIA LONGISPINA* IN UNIVERSITY LAKE, CHAPEL HILL, N. C., MAY 12, 1934



FIG. 6. FORMS OF HEAD OF *DAPHNIA LONGISPINA* FOUND IN UNIVERSITY LAKE IN EARLY SPRING

broadly stated. (2) When females with eggs or embryos in the brood pouch were transferred from high to low temperatures, or vice versa, the newborn with few exceptions had heads characteristic of the one or the other temperature according as the transfer was made before or after the "two-eyed" stage. (3) A few eggs removed from the brood pouch and incubated in drop cultures produced young with the same head form as was to be expected if they had developed under normal conditions. The indications seemed clear—that the influence of temperature acting directly upon the embryo, and not indirectly through the mother, governs the form of the head of the newborn. In isolation cultures one may obtain at will

newborn with no points, small points or large points; this is done by regulating temperature. It should be added, however, that the only forms and sizes of helmets we have been able to induce under experimental conditions are the forms and sizes sometimes displayed by animals of the same race in nature.

On the other hand, without respect to temperature, free-living young almost invariably lost the point to become round-headed within a few molts, and this quite without respect to temperature. In a few cases and under conditions not yet analyzed, points completely or virtually lost were subsequently regained.

Thus the form of head of the newborn is definitely subject to control through regulation of temperature during incuba-



FIG. 7. CONTOUR OF OCCIPUT OF HEADS OF *DAPHNIA* REARED AT 12°C., WITH TRACES OF HELMETS IN THE SHAPES OF BUMP, ANGLE, AND HOOK

tion, but that of the free-swimming animal in cultures is not an evident function of temperature. It does not, however, fol-

low that the fundamental conditions of development of the points on the heads is different in the two cases: the requisite conditions may be temperature plus an unknown factor which is present in all eggs, including those of females that cannot produce points on their own heads, but which may be so deficient in the culture medium as not to be available for the somatic helmet-forming cells.

Again there is a possibility of a helmet-inhibiting factor which does not affect the developing embryos nourished by yolk but which, if present in sufficient quantity, may prevent the retention of a previously formed helmet or even, under extreme conditions, prevent the adults from producing eggs that will produce helmeted young. It is now a purely hypothetical suggestion; but, if such helmet-inhibiting factor were a waste product of metabolism, a key might be found to the occasional and now inexplicable irregularities in the cycle of forms in certain waters or in certain years; to the loss of helmets in shell vials while they are retained in the lake; and to the fact that larger helmets are generally characteristic of larger bodies of water. [The few *Daphnias* that maintained or regained helmets during development in the laboratory were reared in larger containers.] Possibly this will also afford a clue to the alleged correlation of helmet development with geological age of the lake, if the old waters could be assumed to have developed a better condition of equilibrium of populations with less of a tendency to over-production of wastes of a particular species. This hypothetical explanation would account only for irregularities in development and maintenance of helmets, not for the origin or for the diverse forms of helmets.

At any rate, temperature is a significant factor under the conditions of laboratory experiments. We have not been able to

make our *Daphnias* produce helmets at low temperatures and we have not had round heads born at high temperatures, excluding the middle temperatures—11°–15°C. Presumably temperature is a significant factor in nature also, but something else is equally significant both in the laboratory and in the wild; for helmet retention there is required something more than either temperature or the nutritive conditions requisite for growth and prolific reproduction.

ASPECTS OF INTERESTS IN THE PROBLEM OF CYCLOMORPHOSIS IN DAPHNIA

It would seem that the phenomena of cyclomorphosis are of special interest from several points of view:

(1) *Physiology*. Particular groups of cells respond to normal environmental changes in ways that have conspicuous external effects and they do this in a period of just a few days. To what extent can the environmental factors be subjected to experimental analysis to determine (a) which particular one is significant as to form of adult (as temperature governs form of young in our experimental race), and (b) in what degree the influence of one feature of the environment is supplemented or inhibited by that of some other, as our experimental results suggest?

(2) *Heredity*. *Daphnia*, to say nothing of some other Cladocera, gives an appearance of plasticity. In different environments a few rods apart, populations of the same species (as identified in winter) show seasonally characteristic differences which are hereditary. Has the environment had some effect on the genes? Woltereck claims an observable effect, persistent through several generations (*Dauermodifikation*) but gradually reversible in a changed environment. How do the changes in form of whole populations in

new environments, as observed by Woltereck, come into being? As a result of mutation and survival, or as a gradual process in orthogenetic fashion with inheritance of the results of progressive environmental influence? In experimental work directed at such questions, one can deal with pure lines in parthenogenetic reproduction, and also with crosses, taking advantage of the modern technique for inducing sexual reproduction at will.

(3) *Ecology and taxonomy*. Is there any connection between the facts that helmets are not readily maintained in culture dishes and that they are not characteristic of *Daphnia* in small ponds? What is the

distribution of the innumerable special summer forms and what is their relationship to the environmental conditions in the several waters? What are the possibilities of modifying the environment to get changed forms? Genetics, physiology and ecology are peculiarly linked in this problem.

(4) *Evolution*. What has been the mode of origin of the multitude of varieties and subspecies? Is there a possibility of producing new mutations? Can Woltereck's experiments, which seemed to lead to evolutionary modifications without mutation, be repeated with comparable results?

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THE BLOOD OF ARTHROPODS

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"As a tissue or part of the body it performs many functions. . . . Nevertheless, relatively to other parts of the body, blood is a simple system . . . for, metabolic activity and irreversible chemical processes of all kinds are nearly inappreciable, and movement, except in the case of the leucocytes, is imparted from without."

Lawrence Joseph Henderson

AS A *milieu intérieur*, a complete knowledge of the blood requires an understanding of the various processes going on at different times in an animal. While this is true for all tissues it is especially so for the blood. Since, by virtue of an open vascular system, the blood of arthropods, like the lymph of vertebrates, bathes the tissues directly it is termed the haemolymph.

A. TOTAL QUANTITY AND WATER PERCENTAGE OF THE BLOOD

The blood volume of arthropods in general is, when compared with that of vertebrates, relatively large. Thus the blood of a mature silkworm larva (Richardson, Burdette, and Eagleson, '31) and of a *Chironomus* larva (Leitch, '16) is about 50 per cent of the wet weight. In the former case the average value was 0.78 cc. per larva and in the latter 0.008 cc. The wet weight of the pupa of the butterfly, *Pieris brassicae* (Brecher, '29), is about 20 per cent blood. It is a generally known fact that soon after feeding, notably in suctorial forms, the plasma volume increases markedly (Miall and Denny,

1886; Bruntz, '08a; Muttkowski, '23; Haber, '26; Wigglesworth, '31; and others) and the excess fluid is eliminated by way of the Malpighian tubules. In such cases the cuticle is capable of considerable stretch and, in extreme cases, the epicuticle becomes taut instead of wrinkled as it may be during a fast (Wigglesworth, *loc. cit.*). Muttkowski (*loc. cit.*) has expressed such an increase in the plasma volume of the beetle, *Leptinotarsa*, with respect to the blood cells. Thus, the corpuscle-plasma volume ratio of a fully grown starved larva was 1:1; but in the fully fed larvae was 1:60, and in adults about 1:100. In man it is about 1:2. Among endopterygote insects the blood volume attains its zenith in the prepupal period and, among endopterygotes, in the preimaginal period (Muttkowski, *loc. cit.*).

Grapsid crabs (Baumberger and Olmsted, '28) have ten times as much blood ten days after a molt than one day before such. Similarly, the blood volume of the marine crab, *Cancer pagurus* (Paul and Sharpe, '16), is three times as great several weeks after molting than at the approach of a molt (cf. also Robertson, '37). Factors involved in such changes will be treated below. On the other hand, the blood volume of the freshwater crab, *Potamobius fluviatilis* (Herrmann, '31), does not undergo any considerable fluctuations in volume. In certain forms, such as the hermit-crab, *Pagurus* (Maluf, '38a), the maintenance of a fairly constant

blood volume is more important than the existence of a steady blood π .

The water content of the blood varies between 87 and 98 per cent (Witting, 1858; Dohrn, 1861, 1866; Halliburton, 1885a; Griesbach, 1891; Nazari, '02; Ducceschi, '02; Polimanti, '15; Kuroda, '33, '34, '34a; Drilhon-Courtois, '34; Kuwana, '37) depending upon the state of nutrition, hydration, and the rate of growth. During dry weather tardigrades (Shipley, '09) enter into a state of torpor and their watery plasma disappears. After a rain they regain their plasma and their activity.

It should be borne in mind that the blood of arthropods represents their only internal extracellular fluid and is hence equivalent to the blood, lymph, and intercellular fluid, combined, of vertebrates. This consideration lessens the differences in relative quantity between the extracellular body fluids of both phyla.

B. MICROSCOPIC STRUCTURAL ELEMENTS

(1) Condition and distribution

So far as known, the blood of all arthropods contains mobile cells. Muttowski ('24a) made *in vitro* studies of the cells and bodies present in the blood of insects. The living cells present in such blood may be divided into two categories: (1) leucocytes, and (2) parasites such as bacteria (which are regularly present) and Protozoa. In cases, even nematodes were found. The leucocytes are of various grades.

The blood cells of the crayfish, *Astacus fluviatilis* (Tait and Gunn, '18), are of three types: (1) The explosive corpuscles of Hardy (1892) which are 40 to 50 per cent of the total; (2) the thigmocytes (20 to 25 per cent of the total), which are distinguished from the explosive corpuscles chiefly by emitting fine pointed processes when on non-greasy material; (3) the

amoebocytes (about 30 per cent of the total) contain a granular cytoplasm and may be observed in the gill filaments to "undergo constant change of shape, sending out pseudopodia, and migrating from place to place, whereas the other two varieties remain motionless." On the other hand, the blood of *Limulus* (L. Loeb, '07) has only one type of leucocyte and hence should be taken advantage of in studies on the physiology of leucocytes. This is also true for *Daphnia* (Hardy, 1892). Glaser ('18) cultivated the blood

TABLE 1

Cell counts of blood from Crustacea, insects and *Limulus*

| ARTHROPOD | MEAN CELL COUNT/C.MM. ± STANDARD DEVIATION |
|---------------------------------------|---|
| Crustacea: | |
| <i>Crago vulgaris</i> | 8,300 ± 2,700 |
| <i>Palaeomonetes vulgaris</i> | 2,700 ± 800 |
| <i>Homarus americanus</i> | 18,700 ± 6,500 |
| <i>Pagurus pollicaris</i> | 26,000 ± 11,500 |
| <i>Cancer borealis</i> | 14,200 ± 7,200 |
| <i>Uca minax</i> | 12,400 ± 4,400 |
| Xiphosura: | |
| <i>Limulus polyphemus</i> (adult) | 30,000 ± 11,400 |
| <i>Limulus polyphemus</i> (young) | 14,600 ± 5,000 |
| Hexapoda: | |
| <i>Gryllus assimilis</i> (cricket)... | 15,000 to 275,000 |
| Other insects..... | 15,665 to 30,000 |

cells of lepidopterous larvae in their own plasma.

Table 1 gives blood-cell counts made by Tauber and Yeager ('34, '36) and Yeager and Tauber ('35) on the blood from Crustacea, insects, and *Limulus*. As is apparent, there is considerable intraspecies variation and these investigators have observed a modal frequency. Such differences can be explained by the considerable variation in blood volume during various circumstances. Orthopterous larvae have 41 to 72 per cent of the mean cell

counts of the adults. *Limulus* young have about 50 per cent of the mean cell count of the adults. On the other hand, *Leptinotarsa*, *Phyllophaga*, *Photinus*, *Heliothis*, and *Neodiprion* adults have a lower value than the larvae. The total number of blood cells of arthropods, including tardigrades (Shipley, '09), increases with age.

The relative blood-cell content of arthropods is, in general, well below the value in vertebrates. Thus the erythrocyte content in an average human male is 5×10^6 /c.mm. of blood and 4.5×10^6 per c.mm. in females. These values are about 500 times those found in arthropods. Tauber and Yeager ('34) believe that the very low counts given by Hardy (1892) for the crayfish and by Haber ('26) for the cockroach "may well have been due in part to loss of cells by coagulation since these authors apparently used no effective anticoagulant measures."

In the Crustacea listed above and in *Limulus* there was less than one cell undergoing mitosis in every 2,000 cells. This implies a mitotic index of less than 0.5 (or, 0.5 cell/1,000). Mitosis of leucocytes in the Crustacea has also been observed by Löwit (1889, 1891, 1891a), Hardy (1892), Kollmann ('08), and others. Cuénot (1891, 1895, 1897), Bruntz ('06, '07), and Fischer-Piette ('31) have, however, described leucocyte-forming organs in isopod, stomatopod, schizopod, and decapod Crustacea. In insects, haemolymph cell-production occurs, at least chiefly, by the mitosis of the circulating leucocytes (Yeager and Tauber, *loc. cit.*). In spiders, Franz ('03) has believed that blood cells are discharged from the internal epithelium of the heart. The "lymphatic gland" found on the crop of the lobster by Cuénot (1895) has a low mitotic index of 0.1-0.3 (Fischer-Piette, *loc. cit.*) and it has been doubted if this is

adequate to account for the increase in the number of leucocytes with age but no data or calculations have been presented to support such a doubt.

(2) Functions of the blood cells

(a) *Phagocytosis* is the process of ingestion, with or without amoeboid movement, of solid material by a cell. Tait and Gunn ('18) injected powdered quartz, powdered glass, and India ink particles into the haemocoel of a crayfish and noticed that the power of ingesting particles is almost limited to the thigmopositive cells. The amoebocytes were much less phagocytic and the explosive cells not at all so. Even the phagocytic cells were incapable of ingesting simple lipid or greasy particles, such as oil or paraffin, unless an emulsifier were present. Injection of all types of particles except greasy ones caused a great fall in the number of circulating cells. Similar studies have been made on insects by Bruntz ('08) and Métalnikov ('08). The latter found that injected bacteria are ingested, the death rate being in direct proportion to the number of non-ingested bacteria, thus showing that the phagocytes are of significance in disease (cf. also Aghar, '28 and Hollande, '30). In fact, Metschnikoff (1884) developed his classical views on disease-resistance as a result of his observations on the phagocytosis of fungus spores in *Daphnia*.

It has become an established fact that, during the histolytic occurrences in metamorphosis, the leucocytes do not aggressively disrupt the old larval cells but that they may ingest fragments of cells after the latter have become disintegrated and thrown into the haemocoel. In several species of endopterygote insects metamorphic phagocytosis has even never been observed (cf. Snodgrass, '24 and Murray and Tiegs, '35). The *in vitro* and *in vivo*

studies of Glaser ('18) demonstrate that the leucocytes do not engulf bacteria under any circumstances. Similar results were obtained by Friedmann and Schönfeld ('17) on peritoneal leucocytes of guinea pigs.

(b) *Clotting*. The phenomenon in arthropods may involve two distinct processes: (1) Agglutination of blood cells; and (2) protein coagulation. Yeager, Shull, and Farrar ('32) have distinguished three categories of insects with respect to clotting: (1) Those in which no clotting takes place; e.g. certain Homoptera, Coleoptera, Lepidoptera, and Hymenoptera such as the honeybee (Bishop, '23). (2) Those in which clotting is produced solely by leucocytic agglutinations; e.g. certain Orthoptera, Homoptera, Coleoptera, Lepidoptera, Hymenoptera, and Diptera. (3) Those in which clotting is principally a coagulation of blood proteins; e.g. certain Heteroptera, Orthoptera, Coleoptera, and Lepidoptera. They found that in the cockroach, where clotting is essentially a leucocytic agglutination, "many of the blood cells lose their fusiform or discoidal shapes, round up, form thread-like pseudopodia, agglutinate into clumps, spread out and apparently disintegrate." This type of clotting is similar to that in *Limulus*, an animal in which no plasma coagulation occurs and hence in which, contrary to common opinion, serum is not normally formed (Howell, 1885; L. Loeb, '04, '07, '10; Alsberg and Clark, '08). In fact, apart from the cell fibrin, almost the only protein in *Limulus* plasma is haemocyanin (Halliburton, 1885, 1885a; Alsberg, '14) and haemocyanin has been stated to be the only protein in the serum of decapod Crustacea (Halliburton, *loc. cit.*).

Geddes (1879-80) was, however, in error when he considered that the crustacean clot is merely an agglutination.

In phylogeny the Crustacea are the first animals and only marine invertebrates to possess a blood plasma which yields a protein coagulum on exposed standing. Papers dealing with the coagulation of crustacean blood are numerous (Fredericq, 1879; Krukenberg, '1882; Halliburton, 1885, 1885a; Haycraft and Carlier, 1884, 1891; Hardy, 1892; Gruvel, 1894; Cuénot, *loc. cit.*; Hardy, 1892; Ducceschi, '01, '16; Bottazzi, '02; L. Loeb, '03, '05, '06; Nolf, '08; Meyers, '20; Parsons and Parsons, '20; and others). Gruzewska ('32) showed that the blood of the lobster, whether or not deprived of amoebocytes, coagulates rapidly. There are certain Crustacea, such as the crab, *Maia squinado* (Nolf, '08; Parsons and Parsons, *loc. cit.*, Kerridge, '26; Gruzewska, *loc. cit.*, Zunz, '33), and the crawfish, *Palinurus vulgaris* (Zunz, *loc. cit.*), the blood of which does not coagulate even upon the addition of vertebrate thrombin (Nolf, '08, Zunz, '33). In such forms agglutinations may occur (Bottazzi, '02a). The blood of spiders (Blackwall, 1852) clots but that of tardigrades (Shipley, '09) does not.

As regards the process of clotting, in the crayfish (Tait and Gunn), for example, the plasma undergoes two successive coagulations. The first is the result of cytolysis of the explosive corpuscles; the second is supposed to be due to the cytolysis of the thigmocytes. No coagulation results from the cytolysis of the amoebocytes, for, by injecting India ink particles into the haemocoel the number of cells in the plasma is reduced and coagulation is then only partial even though the number of amoebocytes is not reduced. Contact of the blood with any non-greasy foreign matter, such as air particles, sets up cytolysis in what are apparently the thrombin-yielding cells. When the blood is kept in fluid paraffin immediately after removal from the haemocoel the cells remain

intact and no coagulation results. A single corpuscle is capable of producing coagulation in only a limited quantity of plasma. Probably the most thorough description of the process of clotting in insects is that of Muttkowski ('24b). In the species studied, there took place the two distinct steps known to occur in the clotting of the blood of many arthropods, namely, leucocytic agglutination and the coagulation of plasma proteins (fibrin and gelatin). The coagulation of fibrin, the coagulation of gelatin, and the agglutination of the leucocytes possibly occur independently of each other due to the following reasons: (1) A clot of fibrin can occur in decaying insects several days after death, i.e. long after the death of the leucocytes; (2) agglutination is most evident in acidulated drops where little or no fibrin is formed. There were no differences between terrestrial and aquatic insects.

When potassium oxalate is added to the blood of arthropods (in Crustacea, Nolf, '08; in *Limulus*, Loeb, '10; in insects, Muttkowski, '24b) a copious precipitate of calcium oxalate is formed but the blood, in contrast to that of vertebrates, nevertheless clots with the formation of fibrin. Since calcium is unnecessary, the steps toward the formation of fibrin, must, therefore, be at a more ready-at-hand stage in arthropod blood. In vertebrates, thrombokinase does not occur freely in the blood plasma but is apparently liberated into such by rupture of tissue- or blood-cells. The already mentioned work of Tait and Gunn shows that the explosive corpuscles of crayfish liberate a coagulating factor. This substance may be thrombin, for, an assumption of the presence of thrombokinase in arthropods is quite unnecessary knowing that the removal of calcium does not hinder fibrin formation.

There are, however, certain suitable ways by which the blood of an arthropod can be prevented from clotting. Paillot ('23) found that inoculating a drop of 2 per cent nucleic acid in water containing 0.5 per cent Na_2CO_3 and 0.4 per cent NaCl into the haemolymph of an insect, the blood of which normally clots at once when exposed to the air, prevented the blood from clotting. *In vitro* studies of the blood-cells and microorganisms can thus be made. Clotting caused by leucocytic agglutination can be prevented by heating the insects at 60°C. for ten minutes (Yeager, Shull, and Farrar) and by the addition of a large quantity (4-5:1) of K oxalate or peptone to crustacean blood (Gruvel, 1894; Bottazzi, '02a; Parsons and Parsons, '23). This, in Bottazzi's interpretation, apparently prevents coalescence of the leucocytes. In *Prodenia* larvae clotting is "prevented and the insect is killed by immersion in water at 60°C. for 1 minute. There is no visible coagulation of plasma proteins after this treatment" (Babers, '38). Similar results had been reported by L. Loeb ('03a) for *Limulus* and the crab, *Libinia*. Normally autolysed hepatopancreas can inhibit clotting in several species of Crustacea and even acts intergenerically (Numanai, '38). According to Loeb ('03a) it acts on the second clotting, i.e. the fibrin coagulation, of lobster blood.

C. SPECIFIC GRAVITY, REFRACTIVE INDEX, AND SURFACE TENSION

The specific gravity and refractive index of a given liquid varies directly with the amount of material dissolved or suspended in unit volume of the same. The specific gravity of the blood of late instars of silkworm larvae is 1.032-1.039 (Fredericq, 1881; Ducceschi, '02); that of the blood of adult *Dytiscus* and *Hydrophilus* beetles (Barrat and Arnold, '11) is lighter, being

1.025-1.027 and 1.012, respectively; and that of a worker adult honeybee (Bishop, '23) is about 1.045. Judging from the reduction in size of a drop of blood upon drying and hence from its water content, Muttkowski ('23) noted that, in general, the blood of adults is lighter than that of larvae. The specific gravity of *Limulus* plasma is 1.040 (Gotch and Laws, 1884) or 1.03 (Dailey, Fremont-Smith, and Carroll, '31) as contrasted with 1.02 for Woods Hole sea water. This is correlated with the higher concentration of solids in the plasma (= 5.77 gms. per 100 cc.) than in the sea water (= 3.41 gms. per 100 cc.). The specific gravity of the blood of the marine crab, *Platy-carinus pagurus* (Griffiths, 1892), was 1.037, being higher than that of sea water, which was 1.026.

The refractive index of the blood of a *Hydrophilus* beetle (Exner, 1891) is 1.346. Exner made use of this in his classical *in vitro* studies on the optical properties of the insect eye.

The surface tension of the plasma of the marine Crustacea, *Maia squinado* and *Palinurus vulgaris* (Zunz, '33), is, like that of teleosts and octopi, less than that of water, being about 56 dynes per cm. at 18°C. Contrary to Cosmovici ('15), Zunz noted that the surface tension of the blood plasma of mammals and se-lachians is greater than that of water.

D. ACIDITY

(1) The condition

Excessive acidity or alkalinity beyond the vital range (about neutrality) causes death. It may be that the upsetting of the poise of the oxidation-reduction systems of protoplasm, evoked by a considerable variation of acidity beyond neutrality, is the cause of death. Furthermore, an alteration in the reaction of protoplasm beyond certain limits can alter

the isomeric structure of proteins and thus cause the intracellular proteinases to hydrolyze instead of chiefly synthesize protein (cf. Maluf, '37b).

The blood of insects is, in general, slightly acid in reaction (Krey, '37). The statement of Barrat and Arnold ('11) that the blood of the aquatic beetles, *Dytiscus* and *Hydrophilus*, is strongly alkaline to litmus may be dispensed with since it has never been confirmed. Thus, Muttkowski ('23) found that the blood of these beetles is neutral to litmus, i.e. has a pH of ca. 7.0. The blood of various grasshoppers (Bodine, '25, '26) collected under oil to prevent liberation of free CO₂ and tested colorimetrically, has a pH which varies between 6.4 and 7.0. Kocián and Špaček ('34) made colorimetric measurements of the pH of the haemolymph of various adult Coleoptera, including both the Adephaga and Polyphaga. The pH range within a given species did not exceed 0.3. The range throughout the Coleoptera was 6.2-7.2, the haemolymph of the carnivorous forms being more alkaline than that of the herbivorous ones. The pH of a given species, however, remained constant under various diets. No sex differences could be found.

The blood of honeybee larvae (Bishop, '23) has an average pH of 6.83. Higher values (pH 6.93) were found in larvae scattered in the comb and lower values (pH 6.77) in larvae in crowded combs. The difference was considered to be due to the higher atmospheric CO₂ tension in the crowded quarters which would raise the CO₂ pressure of the blood and, therefore, lower the pH. In this regard Florkin's ('34) direct measurements of the CO₂ concentration in the blood of insects should be consulted.

Tisek ('27) bred larvae of the phasmid, *Dixippus morosus*, under constant condi-

tions and found that the pH of the tissues rose continuously with age from a value of 5.5 in the third instar to 6.6 in the eighth. The value of 5.5 is probably too low and it appears that Tisek was influenced by Růžicka's concept of aging. Contrary results were obtained by Muttowski ('23) on *Leptinotarsa*, *Dysticus*, and *Hydrophilus* beetles, in which the blood is neutral to litmus in the adults and a little alkaline to such in the larvae.

Immediately before and soon after molting, the blood pH of the crayfish, *Astacus fluviatilis* (Dohrn, 1866; Damboviceanu, '30), and the crab, *Carcinus* (Jolyet and Regnard, 1877), rises from the range of 7.7-7.8 to the range of 8.0-8.2. This rise is due to a considerable increase in the combined CO₂ content (alkaline reserve) of the blood plasma, this being the result of the liberation of calcium in the blood from the old cuticle and from ingested calcareous material (cf. also Herrick, 1895; '09; Drach, '35a, '35b; Numano, '37). Baumberger and Olmsted ('28) have not, however, been able to find any definite connection between the pH of the blood and the molting process of grapsid crabs. It is possible that the blood of these crabs is exceptionally well buffered. The blood of *Limulus* is slightly basic (Gorch and Laws, 1884).

While the blood of insects is predominantly on the acid side of neutrality, that of decapod Crustacea (both marine and freshwater) and *Limulus* is alkaline. This difference cannot be due to a higher concentration of combined CO₂ (alkaline reserve) in the blood of the latter since such is not necessarily the case. It may be that the difference is due to a low ratio of combined to uncombined CO₂ in the blood of insects (see below).

(2) Regulation of the acid-base balance

The living processes which characterize protoplasm tend to upset its acid-base

balance. Thus, CO₂ liberated into the blood during respiration, acid and alkaline residues taken in with the food, acids secreted with the digestive juices, and lactic acid liberated during muscular activity tend to deviate the pH of the blood from its narrow optimum range which approximates neutrality. The blood of insects (Krey, '37) has a fairly good buffer capacity. The various buffers by which a constant acidity can be maintained are:—

(a) *Blood proteins and amino acids.* These are discussed in a later section.

(b) *Carbonates.* In normal circumstances, the ratio of combined CO₂ to uncombined CO₂ of human blood is ca. 20:1. In the blood of honeybees (Bishop, '23), due to a relatively high free CO₂ concentration (i.e. CO₂ pressure), this ratio is much lower. The total CO₂ concentration of the blood of a honeybee larva is 20-30 vols. per cent, the free CO₂ concentration being 6.6 vols. per cent. Therefore, the ratio of combined to uncombined CO₂ is ca. 4:1. This would account for the rather low pH of the blood of insects, the combined CO₂ being of the same order as that in crustacean blood which has an alkaline pH. In the prepupa the ratio is still less and there occurs a fall in combined CO₂ during the pronounced muscular activity involved in spinning.

There is no definite difference in the total CO₂ concentration between the blood of crustaceans and insects (Winterstein, '09; Collip, '20; Parsons and Parsons, '23; Kerridge, '26; Duval, '27; Duval and Portier, '27; Drilhon-Courtois, '34; Florkin, '34; Pora, '36) the values ranging from 3 vols. per cent in the crawfish, *Palinurus* (Parsons and Parsons; Winterstein), to 89 vols. per cent in *Hydrophilus* beetles (Florkin, '34, '37a, c). Busnel and Drilhon ('37) believe that the high

total CO_2 of the blood of water beetles (*Hydrophilus*, a phytophagous animal, and *Dytiscus*, a carnivorous form) is connected with their aquatic life rather than with their diet. Because of their modes of breathing, CO_2 escape may be slower in these beetles than in other insects. The total CO_2 of *Palinurus* blood is exceptionally low but is compensated for by a low free CO_2 concentration. These animals must, hence, liberate CO_2 in accordance with only the first portion of the per cent CO_2 dissociated— CO_2 tension curve. The high pH of the blood of Crustacea is undoubtedly due to a high ratio of combined to uncombined CO_2 , this being 49:1 in the estuary crab, *Telphusa fluviatilis* (Duval and Portier, '27). Drilhon ('35) has found that the total CO_2 concentration of the blood of a marine or estuary crab varies inversely with the π of the external medium and ascribes the results to the fact that gases and NaHCO_3 are more soluble in fresh water than in salt water.

The combined CO_2 exists mainly as NaHCO_3 and CaCO_3 . Irvine and Woodhead (1888-89) assumed that Ca in the blood of crabs is chiefly in the form of phosphate. From this assumption they presumed that "the existence of alkaline phosphates would preclude the presence of soluble CaCO_3 in any quantity in the blood." It is, however, difficult to conceive how an insoluble compound, such as any form of Ca phosphate, can be held in the blood to any marked extent. Biedermann ('01) and Bütschli ('04) have obtained crystals of both Ca carbonate and Ca phosphate on cooling the blood of lobsters, crabs, and crayfish to 0°C .

Numerous dipterous larvae (Keilin, '21; Eastham, '25) contain deposits of CaCO_3 spherites in the cells of the fat-body. Such larvae are parasitic, phyto-

phagous, or coprophagous. During the first days of metamorphosis, the CaCO_3 dissolves in the haemolymph and passes through the newly formed pupal cuticle into the ecdysal fluid. When this fluid is reabsorbed the CaCO_3 remains as a deposit on the internal surface of the puparium. Larvae of the blowfly, *Lucilia sericata* (Stewart, '34), which feed on dying tissues, exude CaCO_3 through their integument. The capacity of these larvae to accumulate calcium (an alkaline reserve) taken in with their food and the subsequent exudence of such makes possible an alkalization of the surrounding medium, thus allowing predigestion of the necrotic tissues by the trypsinase eliminated with the excreta (cf. also, Hobson, '28).

(c) *Phosphates*. Inorganic phosphorus occurs in fairly marked quantities in the blood of arthropods (Table 4).

(d) *Excretory organs* eliminate uric acid and the bases, urea and ammonia (cf. Maluf, '38).

(e) *Haemocyanin and isohydric changes*. Kerridge ('26) has shown that oxyhaemocyanin is a slightly weaker base, hence a stronger acid, than reduced haemocyanin. Redfield and Mason ('28), '28a) have measured the acid-combining capacity and dibasic amino-acid content of haemocyanin. When haemocyanin is formed in the gill filaments, carbonic acid (H_2CO_3) will be formed from the NaHCO_3 (alkaline) of the blood in the gill filaments due to the momentary decrease in pH resulting from the formation of oxyhaemocyanin from haemocyanin and the consequent combination of oxyhaemocyanin with Na ions liberated from the sodium bicarbonate. The H_2CO_3 will decompose into H_2O and CO_2 and the CO_2 will be liberated to the exterior at the gill filaments. The elimination of CO_2 (and hence of H_2CO_3) will compensate for the momentary de-

crease of pH in the gill filaments resulting from the formation of oxyhaemocyanin. The pH will, therefore, not change over a measurable period, i.e. the change is isohydric. The oxygenation of haemocyanin thus actually aids in the discharge of CO₂.

At the tissues, where CO₂ is liberated into the blood and where the O₂ pressure in the blood is lower than elsewhere, the oxyhaemocyanin liberates its O₂ and becomes a stronger base (i.e. a weaker acid). Part of the carbonic acid which is formed at the tissues is neutralized by the Na liberated from the oxyhaemocyanin when the latter becomes more basic by being transformed into reduced haemocyanin and thus combines with hydrogen ions. Here too the change is thus isohydric. The transport of Na by oxyhaemocyanin enables the latter to act as a buffer compound by liberating Na in the presence of an excess of H₂CO₃, such as occurs adjacent to the cells. In this manner haemocyanin behaves similarly to haemoglobin. As Irving ('37) has pointed out, however, this buffering cannot be of much importance considering the small transport of O₂ by the blood of such animals (cf. also Maluf, '37d).

(f) *Carbonic anhydrase*, which catalyzes the hydration of CO₂ and the dehydration of carbonic acid, occurs prominently in the blood of mammals and is of importance in the transport and elimination of CO₂ in mammals at least (Meldrum and Roughton, '33; Roughton, '35). This enzyme is not appreciably present in the blood of Crustacea and various invertebrates (Florkin, '34c, '35; Robertson and Ferguson, '36; van Goor, '37) but has been found in the Hb-containing blood of *Chironomus* (Brinkman, Margaria, Meldrum, and Roughton, '32). In marine invertebrates, by far its greatest activity is in the gill tissues (Ferguson, Lewis,

and Smith, '37). It is thus evidently of importance in the elimination of CO₂ even in invertebrates.

Prior to the discovery of carbonic anhydrase by Meldrum and Roughton (*loc. cit.*), Henriques ('29) had shown by calculation that the rate of CO₂ formation from the reaction



is too low to account for the rate of CO₂ discharge from the lungs. He hence postulated a loose combination of CO₂ with Hb (into carbhaemoglobin). This, however, could not be verified by subsequent experiments and the discovery of carbonic anhydrase came as a pleasant solution to the dilemma. The recent discoveries that many invertebrates are capable of transporting Cl ions up a steep concentration gradient by way of their integument or gills may be of significance with regard to a Cl shift for the discharge of CO₂.

E. OSMOTIC PRESSURE

Since arthropods, by virtue of their open vascular system, have only one internal extracellular fluid but nevertheless are not generally isotonic to their environment, they make excellent subjects for studies on osmoregulation and its attendant transfer of water and solutes.

(1) *Terrestrial and freshwater forms*

(a) *In their natural environment.* The Δ of the haemolymph of insects, both aquatic and terrestrial, varies between 0.47 and 0.95 with a mean of ca. 0.55, depending upon the species (Ducceschi, '02; Widmark, '10; Barratt and Arnold, '11; Backman, '11, '12; Polimanti, '15; Duval, '25; Portier and Duval, '27; Harnisch, '34; Drilhon-Courtois, '34; Fox and Baldes, '35; Wigglesworth, '38). The haemolymph, except in certain larvae

inhabiting sea water, is always hypertonic to the external medium, the Δ of the latter being 0.02–0.03 (Fredericq, 1898; Garrey, '05). In most cases they have a lower blood π than marine arthropods and one that approaches that of mammals including man ($\Delta = 0.56$). Backman ('11, '12) obtained consistent results with insects in their native media and found the Δ to remain constant before and after metamorphosis. This, however, is not true for the silkworm (Polimanti, '15), the blood Δ of which varies markedly during development.

The blood Δ of the crayfish, *Astacus fluviatilis* (Fredericq, 1898; Duval, '24; Herrmann, '31; Schlieper, '35) is about 0.80 and that of the crayfish, *Cambarus clarkii* (Lienemann, '38), varies between 0.568 and 0.718 (av. = 0.644) when the animal is in its normal medium (fresh water). According to Fritzsche ('17) the blood Δ of *Daphnia pulex* is as great as 2.0. Soon after molting and during starvation the π of the blood of freshwater decapod Crustacea (Schwabe, '33; Scholles, '33; Huf, '33) of *Daphnia* (Fritzsche), and of mosquito larvae (Wigglesworth, '38) declines slightly.

The integument of the gill filaments of certain freshwater arthropods, such as larvae of the mosquito *Aedes argenteus* (Wigglesworth, '33b), the midge *Chironomus* (Harnisch, '34; Pagast, '36; Koch, '38), and crayfish (Maluf, '37a), is extremely thin and freely permeable to water. The water that is continuously absorbed is eliminated as a markedly hypotonic and relatively copious urine (Fig. 1, E) by the Malpighian tubes, rectal cells, and antennal kidneys respectively (Wigglesworth, *loc. cit.*; Harnisch, *loc. cit.*; Herrmann, '31; Schlieper and Herrmann, '30; Schlieper, '30, '35; Peters, '35), the work of secretion evidently being supplied by energy liberated by

oxidations as indicated by a rise in the oxygen consumption rate of euryhaline brackish-water forms when in fresh water and a fall in the rate when in stronger saline (Schlieper, '29, '31; Schwabe, '33; Bateman, '33; Fox and Simmonds, '33; Raffy, '34; Löwenstein, '35; Peters). More recently, Schlieper ('36) and Pich ('36) have abandoned the latter concept after noting that the euryhaline invertebrates, *Eriocheir sinensis*, *Clava multicornis*, and *Pelmatohydra oligactis* consume oxygen at the same rate in hypertonic sea water or brackish water as in fresh water. Upon reviewing literature bearing on the subject, they came to the conclusion that the only common factor to a rise in oxygen consumption in hypotonic media is an increased water content of the tissues. A lowering of the O_2 consumption in hypotonic media is held to be due to tissue-hydration beyond the limit of tolerance. It should be noted, however, that the rate of oxygen consumption of the completely stenohaline crab, *Pagurus longicarpus* (Maluf, '38a), declines with a decrease in the tonicity of the sea water even after osmotic equilibrium is attained and even when the lower limits of complete tolerance to dilution are not approached. It is possible that the permeability of the surface of the above-mentioned euryhaline invertebrates becomes practically impermeable to water when in fresh water or that the osmotic work performed is relatively too small to have lent itself to measurement.

Since some salts are lost even in such a hypotonic urine, these must be compensated for either by feeding, as in the eel (Krogh, '37a, b) or by a secretion of salts against the osmotic gradient, as in the frog, certain freshwater fish, crayfish, earthworms, and the anal gills of certain mosquito and chironomid larvae (Krogh, '37a, b, c, d; Koch and Krogh, '36; Koch, '38; Wigglesworth, '38; Maluf, '39a, b).

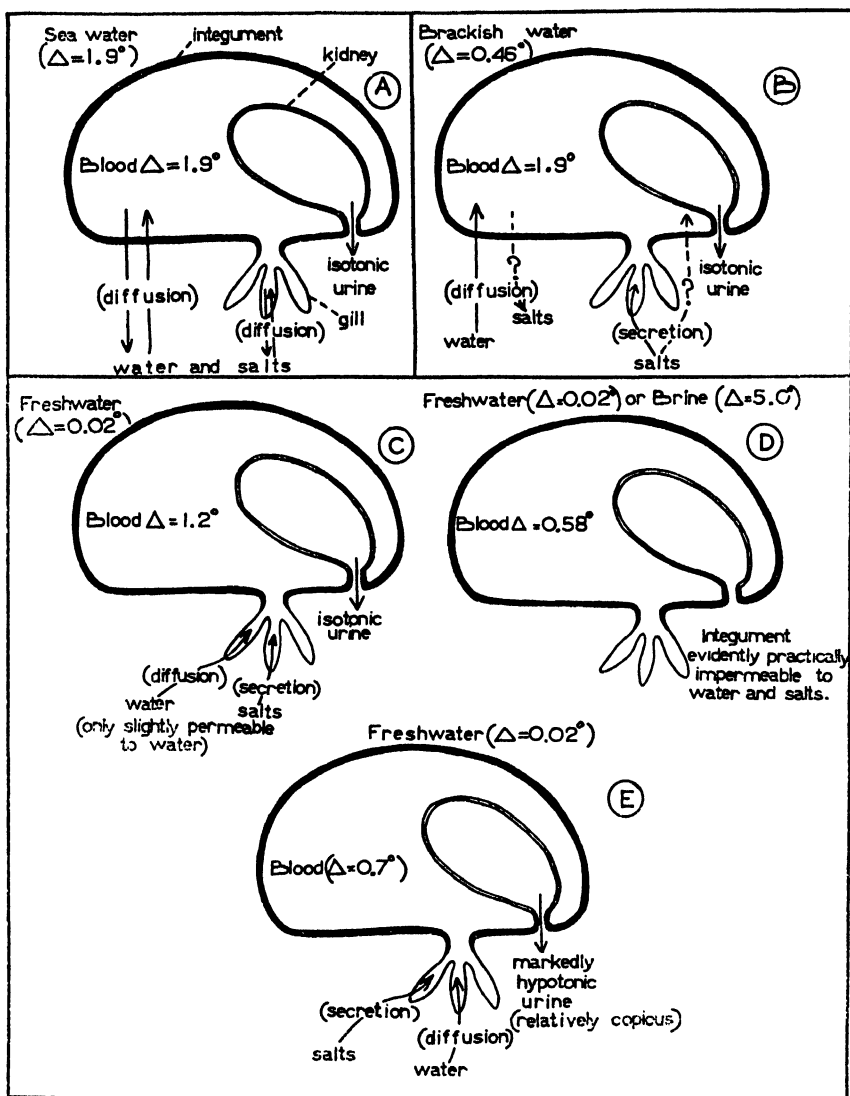


FIG. 1. SCHEME INDICATING HOW ADULT MARINE ARTHROPODS MAY HAVE INVADDED FRESH WATER BY WAY OF THE BRACKISH WATER ESTUARIES

(A) Completely stenohaline (poikilosmotic) form confined to the sea and incapable of inhabiting brackish water (e.g. *Homarus*, *Palinurus*, *Pagurus*). (B) A partially homoiosmotic form confined to the sea and brackish water and incapable of inhabiting fresh water (e.g. *Carcinus maenas*, *Mesodotea entomon*). (C) An incompletely homoiosmotic form nevertheless capable of inhabiting fresh water, brackish water, or the sea (e.g. *Eriocheir sinensis*, *Telphusa fluviatilis*). (D) Almost completely homoiosmotic form capable of inhabiting and breeding in brine or fresh water (e.g. *Culex mariae*). (E) Specialized freshwater form incapable of living in the sea but capable of living indefinitely in isotonic balanced salinel without a marked change in the blood π . It cannot live in the sea probably mainly because of the fact that its kidneys invariably secrete a blood-hypotonic urine (e.g. *Cambarus*).

When the external orifices of the kidneys of the crayfish are sealed the animal increases in weight due to the absence of an outlet for the absorbed water (Herrmann, '31). The blood π is nevertheless not lowered under such conditions; and not even when a pincer is amputated with a resultant admission of 14 cc. of fresh water into the haemocoel. This is because of a discharge of salts from the muscles (Scholles, '33).

Certain aquatic insects are particularly resistant to salt loss and evidently possess an integument that is practically impermeable to water thus making the almost continuous formation of a urine unnecessary. Backman ('12) kept water beetles (*Dytiscus* and other genera) in distilled water for 288 hours without food and could find no change in the Δ of the blood.

(b) *In saline media.* Backman ('12) kept aquatic beetles in 2 to 3 per cent NaCl (3.7 to 5.6), 31.6 per cent sugar, or 6 per cent urea and noted a rise in the blood and eventual death. Dragonfly larvae (Backman, '11) were more resistant. *Chironomus* and ephemerid larvae, and Crustacea such as *Cladocera*, *Daphnia*, *Cyclops*, and *Astacus* perish sooner or later in sea water (Bert, 1871; Fritzsche, '17; Raffy, '34), their duration in such varying inversely with the temperature (Dernoscheck, '11; Koidsumi, '28). The crayfish *Astacus* (Duval, '25; Drilhon-Courtois, '34) is, unlike *Daphnia* (Fritzsche), almost completely resistant even to hypertonic salinities provided the Δ of the latter is less than 1.85. Under such conditions the urine becomes scantier, its Δ increases but always remains considerably hypotonic to the blood, and the blood Δ increases somewhat. *Cambarus* (Lienemann, '38) has evidently a greater osmoregulatory capacity than *Astacus* since, when the former is placed in blood-isotonic NaCl, there is no appre-

ciable rise in its blood Δ but the urine Δ increases to 0.32 (from a value of ca. 0.065) in 16 days. Probably because of an occasional swallowing of the pure NaCl "the transition from fresh water to salt water seems a difficult one for *Cambarus*, for 15 out of the 19 mortalities occurred in the first 4 days. Only 4 crayfish died in the succeeding 28 days" (see also Helff, '31, as regards this matter). The writer ('39a) has demonstrated that a crayfish does not swallow its medium when in fresh water.

In brackish water (up to a Δ of 0.88) the hemipteron, *Sigara* (syn. *Corixa*) *lugubris* (Claus, '37) loses water even when the saline medium is hypotonic but, nevertheless, maintains a constant blood π ($\Delta = 0.75$) by discharging chlorids to the exterior against an osmotic force. An allied species, *S. distincta*, is not as efficient in this respect. It is possible that salts affect the permeability of their integument since weight loss does not occur when in distilled water and is inappreciable in fresh water.

Ramult ('25) has found it possible to acclimate *Daphnia* and *Cyclops* to 50 per cent sea water. Pure salts are more toxic than sea water (Ostwald, '05; Koidsumi, '28, '31; Berger, '29-'30; Helff, '31). It is probable that where hypotonic solutions of pure salts have a lethal effect on fresh water arthropods (e.g. NaCl on *Daphnia*, Ostwald, *loc. cit.*) the results are due to an (occasional) swallowing of the external medium.

(c) *Drying.* If the aquatic beetle, *Dytiscus* (Backman, '12) is kept in dry air for several hours its blood Δ can increase to 1.4 or more.

(2) Estuarine crabs

Telphusa fluviatilis, *Eriocheir sinensis*, and *Sesarma* n. sp. are capable of living indefinitely in both fresh water and sea

water even without being acclimatized (Dakin and Edmonds, '31; Berger, '31; Drilhon-Courtois, '34, '34a; Schlieper, '35). Since they eliminate a blood-isotonic urine even when in fresh water (cf. Schlieper, *loc. cit.*), their integument has been assumed to be almost impermeable to water. Raffy ('34) nevertheless found that the oxygen consumption rate of *T. fluviatilis* is greater in fresh water than in sea water and Krogh ('37c) has noted that *Eriocheir* is capable of active absorption of Cl— from the exterior against an osmotic force (Fig. 1, C) and according to its requirements.

These animals maintain a constant blood-ion concentration when in fresh water but lose K or Ca from their blood when put in K-free or Ca-free sea water, respectively (Berger, '31; Drilhon-Courtois, '34). The converse occurs when placed in sea water with an abnormally high K or Ca concentration (Berger, '31). Since this occurs even when the mouth is plugged and the anus is ligated, Berger suggested that, when in fresh water, there is a lowering of the permeability of the integument to ions. This is similar to the conclusion drawn by Adolph and Adolph ('25-26) and Maluf ('39b) with regard to earthworms and planarians—animals which maintain a constant weight in fresh water but which decrease in weight in hypotonic saline. An alternative and more plausible suggestion (and the only one necessary in view of Krogh's results with *Eriocheir*) is that, as in *Carcinus maenas*, these crabs are capable of actively withdrawing salts from hypotonic media.

When in sea water, the blood π of the estuarine crabs rises (Drilhon-Courtois, Berger) from its state ($\Delta = 1.18$) in fresh water to approximate isotonicity with the sea water, although the increase is somewhat buffered by a marked decrease in the

concentration of blood protein (Drilhon-Courtois, '34). This is also true of the crayfish and the euryhaline crab, *C. maenas*. It is not known how the estuarine and shore crabs (see below) maintain a constant hypotonic blood π when in sea water. It is conceivable that they may be capable, like eels (Keys, '31), of secreting salts to the exterior.

(3) Marine forms

(a) *In their natural environment.* The blood Δ of marine arthropods is, in general, very nearly equal to that of the environment ($= 1.80-2.4$) and thus varies according to the salinity of the marine habitat (cf. Macallum '02-'03, '26; Fredericq '04; Garrey '05; Duval '24, '25; Schlieper '30, '35; Dailey, Fremont-Smith and Carroll '31; Maluf '38a and numerous others mentioned in this paper; Fig. 1, A) and is generally over three times greater than that of freshwater forms.

There are, however, certain species (euryhaline forms) which are capable of dwelling in an osmotically varied environment without as marked changes in their blood π and of normally maintaining a blood π that is markedly different from that of the surrounding sea water. Among such are the already mentioned estuary crabs. The blood of the Baltic Sea isopod, *Mesodotea entomon* (Bogucki, '32), which cannot endure fresh water, has a Δ of 1.07 while that of its environment is only 0.41. Since this animal cannot live in fresh water or extremely diluted sea water, it appears that, as in *Carcinus*, it actively secretes salts from the exterior into its blood. The π of the blood of the crabs *Carcinus maenas* and *Heteropanope tridentata* (Duval, '25; Margaria, '31; Bateman, '33; Schwabe, '33; Otto, '34) which are capable of living indefinitely in brackish water, is generally

higher than that of the external medium even when the latter is regular sea water. Other shore crabs, such as *Eriphia spinifrons* (Schwabe), *Pachygrapsus* (Baumberger and Olmsted, '28; Schwabe), *Heloeccius cordiformis*, *Leptograpsus variegatus*, *Sesarma erythroactyla* (Dakin and Edmonds, '31; Edmonds, '35) have a blood π ($\Delta = ca. 1.96$) which is maintained below that of the surrounding sea water ($\Delta = ca. 2.14$).

The blood π of Crustacea (Widmann '35-'36) falls during starvation or during rise in temperature.

The mechanism of osmoregulation in *C. maenas* (Fig. 1, B) has been the subject of an admirable study by Nagel ('34) in Carl Schlieper's laboratory at Marburg. The salt concentration of the urine of this species is equal to that of the blood but, probably due to the presence of quantities of organic material in the latter, the π of the blood is higher than that of the urine when the animal is in brackish water. In this connection it is of interest to note that the protein concentration of the blood of *C. maenas* (Drilhon-Courtois, '34) varies inversely with the π of the external medium. It is nevertheless clear that the kidneys of this animal have no osmoregulatory function as far as the maintenance of a constant mineral concentration in the blood is concerned. Therefore, there must be another factor which maintains a constant hypertonic blood π in spite of salt loss through the kidneys. Nagel's experiments show that the integument (presumably of the gills) can secrete salts into the blood from a hypotonic medium according to the extent of salt depletion.

At the approach of molting, the blood π of crabs and isopods (Baumberger and Olmsted, '28; Huf, '33; Schwabe, '33; Scholles, '33; Widmann, '35-'36; Robertson, '37) rises markedly. Taking into

consideration that the glycogen content of the hepatopancreas of *Carcinus maenas* (von Schönborn, '10) is more than twice as great just prior to molting than after, Baumberger and Olmsted suggested that the rise in the blood π at the approach of molting is due to the breaking up of glycogen in the hepatopancreas into glucose and lactic acid, which would be released into the blood. But, as a result of analyses, Baumberger and Dill ('28) later found "that in no case could the conversion of glycogen to sugar sufficiently raise the osmotic pressure of the blood to account for the freezing point depressions observed." They could, however, explain the subsequent decline (see also Schwabe, '33 and Scholles, '33 for other species) in the blood π sheerly on a dilution basis, i.e. as the result of the absorption of water but not of salts. The site of water intake was not determined but it was assumed to occur *per os*. This, however, does not seem probable to the writer since the blood π would not fall well below that of the external medium because of salts which would have to be absorbed through the gut. The imbibition of water increases the blood pressure and thus aids ecdysis and the expansion of the new integument. Almost two decades earlier von Schönborn ('11) had observed that the percentage of total solids in the whole body of newly molted individuals of the crab, *Maia squinado*, is about one-third that of individuals within intermolt periods.

Since, with the possible exception of a few brine species (see below), the integument of all marine arthropods is permeable to salts (cf. Berger, '31; Bethe, '34; Maluf, '38a), it is no wonder that they cannot withstand isotonic unbalanced saline solutions (see, for instance, Loeb, '03; Barnes, '32, '34, '35).

(b) *In hypotonic media.* Apart from the

above-mentioned euryhaline or partially homoiosmotic forms, the stenohaline (completely poikilosmotic) forms are capable of a certain degree of dilution. But just as freshwater arthropods cannot exist with a blood π as great as that of sea water, marine forms cannot endure a blood π as low as that of the freshwater denizens. The reasons for such intrinsic differences are not known although it appears that, in general, the marine inhabitants cannot withstand anywhere near as great dehydration as they can dilution (Maluf, '38a), i.e. they are living within their upper limits of osmotic pressure. Even among marine forms, resistance to dilution is not uniform. Thus, the hermit crab, *Pagurus longicarpus* (Maluf, '38a), can continue to have a normal heart rate in 50 per cent sea water while the heart of *Aplysia* (marine snail), *Octopus*, and the prawn, *Palinurus* (Fredericq, '22), ceases to beat instantaneously if perfused with 50 per cent sea water even though the sea water at Naples is considerably hypertonic to that of Long Island Sound. The latter species are probably less subject to dilution in nature. A marine amphipod, *Gammarus* (Loeb, '03), will die in a short time in 1/10 sea water but can permanently withstand 1/2 sea water. The isopod, *Ligia oceanica* (Tait, '16; Bateman, '33), swells and dies in 1/2 sea water. The lobster, *Homarus americanus* (Garrey, '05), dies within six hours in 1/2 sea water ($\Delta = 1.02$) when the blood Δ arrives at 1.32. The latter value is considerably higher than that of its freshwater relative, the crayfish. When the blood Δ of *Limulus* (Garrey, loc. cit.) equals 0.90° the gill filaments burst owing to excessive internal pressure. The soft abdomen of the hermit crab, *Pagurus* (Maluf, '38a), often bursts in 1/2 sea water.

In all cases the dilution curves are

logarithmic indicating an integument freely permeable to water.

Summing up, arthropods which can live indefinitely in the sea may be categorized thus with regard to their status in hypotonic media:

(i) Those which are practically independent of hypotonic media; e.g. larvae of the mosquito, *Culex mariae*—in truth of freshwater ancestry.

(ii) Those the blood π of which is decreased but only to a certain level and which can live indefinitely in fresh water without acclimatization; e.g. the estuary crabs.

(iii) Those the blood π of which is decreased only to certain level in brackish water but which, as far as is known, cannot live indefinitely in fresh water or extremely dilute sea water; e.g. the shore crabs, *C. maenas* and *Sesarma erythrodractyla*.

(iv) Those entirely incapable of osmoregulation; e.g. *Maia*, *Pagurus*, *Platycarcinus*, *Homarus*, *Limulus*.

(c) In hypertonic media. Certain arthropods, of freshwater ancestry, are known to live and breed in a markedly hypertonic medium such as brine; e.g. the Diptera *Stratiomys* (Henneguy, '04), *Aedes zammitii* (de Vogel, '07), *Culex mariae* (Sergeant, '09), and the branchiopod, *Artemia salina* (Medwedewa, '27). A rise in the π of the brine from $\Delta = 2.65^\circ$ to $\Delta = 4.98^\circ$ produces a rise in the blood π of *Artemia* from $\Delta = 0.74^\circ$ to only 0.80° . *Artemia* is one of the few branchiopods which has adopted a marine habitat. Herbert Warren (cf. Boon and Baas-Becking, '31) has shown that *Artemia* has "in the muscular mechanism of its loop-shaped proctodaeum a most efficient means of closure of the gut." It can thus live for days even in solutions of potassium permanganate, potassium bichromate, and potassium nitrate. Unlike its dipterous brine neighbors, *Artemia* (Medwedewa) is incapable of inhabiting hypotonic media. This may be due to the

fact that it has an integument permeable to salts and that it possibly has learnt to secrete salts only to the exterior and not to the interior, against an osmotic force.

Crabs, such as *C. maenas* and *E. spinifrons*, which have been noted to be capable of considerable osmoregulation in a hypotonic medium are, however, almost as susceptible to hypertonic media as *Maia* or *Platycarcinus*. The reason for this becomes clear when their method of osmoregulation and the fact that Crustacea cannot excrete a urine hypertonic to the blood are borne in mind.

(d) *Drying* raises the blood π (Garrey, '05; Bateman, '33). When the chlorid concentration of the blood of *C. maenas* (Bateman) attains the value of 0.815 M, whether because of drying or of sojourn in a hypertonic medium, the crab dies thus indicating that the effects of drying can be the same as those of hypertonic media.

F. SUBSTANCES OF THE HAEMOLYMPH

(1) Mineral salts

The fact that the blood of most marine Crustacea is isotonic to the environment does not imply that the proportions of the various major ions are the same in both the external and internal media. Table 2 shows that among marine forms (except the Baltic Sea isopod, since that sea has a relatively low salt concentration, and with the exception of *Palinurus vulgaris*) the [Na] is somewhat lower in the blood than in the sea water; the [Mg] is much lower in the blood while the [Ca] and [K] values are a little higher in the blood. The [Cl] of the blood is a little less than that of the environment. This condition is exemplified thus in Macalulum's ('26) fascinating paper (Na being arbitrarily taken as 100):

| ELEMENT | Na | K | Ca | Mg | Cl | SO ₄ |
|--------------------------|-----|------|------|------|-------|-----------------|
| Ocean water..... | 100 | 3.61 | 3.91 | 12.1 | 180.9 | 20.9 |
| <i>Homarus</i> blood.... | 100 | 3.73 | 4.85 | 1.72 | 171.2 | 6.67 |

The relative differences in ionic concentration are evidently, at least mainly, due to selective secretion by the kidneys rather than to selective absorption by way of the gut, as shown by plugging the mouth and ligating the anus (Scholles, '33). The relative mobilities of the passage of the ions through the integument can scarcely be a factor, as Pantin ('31) suggests, partly because these differences might be cancelled by the same relative mobilities through the kidney membranes. Robertson ('37) has pointed out that the presence of colloids in the blood accounts, at least partly, for the higher value of Ca in the blood of *C. maenas* than in the surrounding sea water.

The blood of most marine arthropods is raised to the level of that of sea water by other blood constituents, such as urea, amino acids, proteins, trimethylamine (?), and glucose. But Myers' ('20) determinations exemplify the fact that the major component of the blood π is due to the minerals in solution and not to organic constituents as in elasmobranchs (Myers) and insects (see below). The total mineral salt concentration of the blood of freshwater Crustacea is lower than that of marine forms but the [Ca] is about equal in both groups. Calcium is necessary for the formation of the cuticle and it is well known that crayfish do not inhabit freshwater bodies deficient in Ca; e.g. those of Long Island, N. Y. They undoubtedly obtain most of their Ca supply by feeding on Ca-rich material when renewing their cuticle.

The concentration of total phosphorus in the blood of the crab, *Maia squinado* (Drilhon, '33b), remains approximately

constant at all stages. Upon molting the mineral P undergoes a decline, being probably then utilized in the formation of the tricalcium phosphate of the new cuticle—the principle mineral salt of such (Herrick 1895, '09)—and probably not as Drilhon (now Drilhon-Courtois) would have us suppose, converted into organic P. Even though the blood of decapods is, by dilution, considerably augmented in volume after molting, the [Ca] nevertheless remains constant (Paul and Sharpe and Damboviceanu). This is probably due to a liberation of Ca stored in the hepatopancreas (cf. Maluf, '37b) and muscles (Scholles, '33).

The blood of terrestrial forms (insects) is relatively rich in K and inorganic P but very poor in Cl and Na (Table 2). When compared with mammalian blood it has much less Na and Cl but much more K, Ca, P, and particularly Mg. Assuming the analyses to be accurate, it is at present inexplicable why insect organs are more sensitive to deficient Na and excess K in the perfusion medium than are vertebrate organs (cf. Clarke, '27; Hobson, '28; Maluf, '38c). The reason for this marked discrepancy may be due to the fact that in all cases the *total* [K] of the blood was determined and not solely the *ionized* [K]. Nevertheless, even if all the purine in the blood were considered to be in the form of the dibasic salt, K_2 urate, this would account for only about 7 mg. per cent of the blood K leaving the remaining about 120 mg. per cent unexplained for. It is possible that some of the K is united to amino acids and proteins, with which the blood of insects is especially rich.

The blood of insects (Muttkowski, '23) contains Cu and Fe in unknown quantities. The total mineral concentration of the blood can account for only $1/4$ of its π (Bishop, Briggs, and Ronzoni, '25), being

much lower than that of marine arthropods, freshwater Crustacea, and mammals; and the elements are not present in the same relative proportions as found in sea water, marine arthropods, and vertebrates. Most of the blood π of insects is due to organic molecules, chief of which are the abundant free amino acids (Table 4). While the Na, reckoned as NaCl, explains only *ca.* 4.5 per cent of the total molecular concentration of the blood of moths (Drilhon, '34), that of marine Crustacea accounts for 90–95 per cent of such. The high total [K] of the blood of insects may bear some relation to their vegetable diet and its probable significance has been pointed out above. It is only fair to say that we know practically nothing of the *ionic* [K] in insect blood. The relative concentration of elements in the blood of a crayfish and an insect are nevertheless shown below (Na arbitrarily taken as 100). Even with [Na] used as a reference, the composition of the blood of insects departs widely from that of sea water.

| ELEMENT | Na | K | Ca | Mg | Cl |
|-----------------------------|-----|------|------|-------|------|
| <i>Cambarus</i> blood . . . | 100 | 5.27 | 4.53 | 0.71 | 47.2 |
| Honeybee larva . . . | 100 | 730 | 111 | 161.5 | 895 |

(2) Carbohydrates

So far as known, glucose is the only form in which carbohydrate is transferred from the gut to the tissues. While professing to be analyzing the [glucose] of the blood of various arthropods, Morgulis ('23), Myers ('20), Blumenthal ('27), Beutler ('36), and others were actually including all other reducing substances in the blood (Table 3). The methods used by them do not take into consideration disturbing factors (e.g. glutathione, ascorbic and uric acids), which Hemmingsen ('24) and Florkin ('37c)

TABLE 2
Mineral content of the blood of arthropods in their natural media
(Mgm./100 cc.)

| ARTHOPOD (ADULT UNLESS OTHERWISE STATED) | Na | K | Ca | Mg | Cl | P (INOR- GANIC) | S (NON- PRO- TEIN) | Fe | INVESTIGATORS |
|---|--------|-------|------|-------|--------------------------|-----------------------|-----------------------------|------|--|
| Terrestrial (insects): | | | | | | | | | |
| <i>Pieris brassicae</i> (pupa) . . . | traces | 137.8 | 33.0 | 56 | 59.5 | 66.0 | — | — | Brecher ('29) |
| <i>Diilephila euphorbiae</i> (larva) | — | — | 41.0 | 43.5 | 48.6 | 12.0 | — | 5.8 | Heller and Moklow- ska ('30) |
| <i>Prodenia eridania</i> (larva) | 51.2 | 155.0 | 36.8 | 17.2 | 119.8 | 17.6 | 44.4 | — | Babers ('38) |
| Various lepidopterous larvae and pupae . . . | — | — | — | — | 16-97 | — | — | — | Portier and Duval ('27) |
| <i>Dytiscus marginalis</i> . . . | — | 125 | — | — | 224 | — | — | — | Portier and Duval ('27), and Busnel and Drilhon ('37) |
| Pupae of various moths (av.) | 14.7 | 164 | 30.5 | — | — | 22.5 | — | — | Drilhon ('34) |
| Honeybee larva | 13 | 95 | 14.4 | 21 | 116.5 | 31 | traces | — | Bishop, Briggs, and Ronzoni ('25) |
| <i>Leptinotarsa decimlineata</i> | — | 111 | — | — | — | — | — | — | Busnel and Drilhon ('37) |
| <i>Hydrophilus piceus</i> | — | 82.8 | — | — | — | — | — | — | Busnel and Drilhon |
| Fresh-water: | | | | | | | | | |
| <i>Astacus fluviatilis</i> (crayfish) | 322 | 14.04 | 66.6 | 17.0 | — | — | — | — | Bernard ('33) |
| <i>A. fluviatilis</i> | — | — | 55 | — | — | — | — | — | Damboviceanu ('30) |
| <i>A. fluviatilis</i> | 488 | 19.0 | 56.0 | — | — | 0.9 | — | — | Drilhon-Courtois ('34, '34a) |
| <i>A. fluviatilis</i> | — | 20.0 | 42.0 | 6.0 | 691.0 (copper = 27.4) | 21.4 | 20.1 | 21.2 | Schlieper ('35) and data of Dohrn (1866) |
| <i>Cambarus clarkii</i> (cray- fish) | 877 | 46.2 | 39.7 | 6.2 | 414.3 | 0.47 | — | — | Lienemann (1938) |
| <i>Telphusa fluviatilis</i> (in fresh water) | 775 | 33 | 72.3 | — | — | 1.0 | — | — | Drilhon-Courtois (loc. cit.) |
| <i>T. fluviatilis</i> (in sea water) | 1,220 | 63 | 96.5 | — | — | 0.3 | — | — | Drilhon-Courtois |
| Marine: | | | | | | | | | |
| <i>Mesodonta entomon</i> (of the Baltic Sea) | 464.0 | 24.0 | 50.0 | 28.0 | 730.0 | 4.0 | 23.0 | — | Bogucki ('32) |
| <i>Limulus polyphemus</i> (Woods Hole) | 1,016 | 50.1 | 38.9 | 118.5 | 1,774 | 12.2 (copper) | — | 0.68 | Dailey, Fremont- Smith, and Carroll ('31) and data of Gotch and Laws (1884) |
| <i>Cancer productus</i> } <i>C. antennarius</i> } | 1,757 | — | 52.1 | — | — | — | — | — | Meyers ('20) |

TABLE 2.—*Concluded*

| ARTHOPOD (ADULT UNLESS OTHERWISE STATED) | Na | K | Ca | Mg | Cl | P (INOR- GANIC) | S | Fe | INVESTIGATORS |
|--|-------|-------|------|-------|-------|-----------------------|------|----|---|
| Marine:—Continued: | | | | | | | | | |
| <i>Carcinus maenas</i> | 1,300 | 51.0 | 50.0 | 94.0 | 2,160 | — | — | — | Duval ('24), Bethe ('28-'29), Schlieper |
| Various crabs..... | 1,300 | — | — | — | — | — | — | — | Duval |
| <i>Maia squinado</i> | — | — | — | — | — | 20-52 | — | — | Drilhon ('33) |
| <i>Palinurus vulgaris</i> | 2,180 | 98 | 98 | 54 | 2,160 | — | — | — | Schlieper |
| <i>Homarus vulgaris</i> | 1,300 | — | — | — | — | — | — | — | Duval |
| <i>H. americanus</i> | 903 | 33.7 | 43.8 | 15.6 | 1,547 | — | 24 | — | Macallum ('26) |
| <i>H. americanus</i> | 987 | 53.8 | 97.2 | 20.4 | 1,575 | — | 13.4 | — | Cole <i>et al.</i> ('38) |
| Crabs and lobsters..... | — | — | — | — | — | 6.50 | — | — | Gautrelet ('02) |
| External media: | | | | | | | | | |
| Naples Bay..... | 1,960 | 43 | 45 | 219 | 2,227 | — | — | — | Schlieper |
| Woods Hole..... | 1,004 | — | — | — | 1,831 | — | — | — | Dailey, Fremont- Smith, and Carroll |
| “ “..... | 880 | 41.2 | 42.8 | 130.0 | 1,835 | 0.67 | 87.1 | — | Page ('27) |
| Baltic Sea..... | 188 | 7 | 11 | 24 | 360 | — | 19 | — | Bogucki |
| Tap water (Ithaca, N. Y.)..... | 12.6 | trace | 4.4 | 1.1 | 0.7 | 0.12 | — | — | Lienemann ('18) |

have shown to be of overwhelming magnitude in the blood of crayfish and insects, respectively. Hemmingsen allowed yeast cells to hydrolyze the glucose in the blood and compared the results before and after yeast action. His data on crayfish make the presence of glucose in the blood of this animal, at certain periods at any rate, very doubtful. One-half to five-sixths of the total reducing substances in the blood of various species of Lepidoptera (Kuwana, '37; Babers, '38) and of the beetle *Hydrophilus* (Florkin, '37c) was not glucose. On the other hand, all the reducing material of the blood of *Limulus* (Dailey, Fremont-Smith, and Carroll, '31; Fremont-Smith and Dailey, '32) and various decapod Crustacea (Florkin, '37c), is fermentable by yeast and not appreciably affected by HCl hydrolysis. Demianowski and Prokoffjewa ('35), Florkin ('36b, '37b) and Kuwana (*loc. cit.*) have determined the variations in glycaemia of the silkworm at various postembryonic stages.

The [glucose] of the blood of some

Crustacea (*Carcinus*, *Portunus*) declines during short starvation (Stott, Hemmingsen). Roche and Dumazert ('35) have, however, noted that the glucose concentration of the blood of *Cancer pagurus* is not appreciably modified by a fast. There is, thus, evidently a regulation of glycaemia in some crabs. Furthermore, Stott and Hemmingsen were really determining *total* copper-reducing substances in the blood and not merely glucose. Under oxygen deficiency, in which the rate of glucose oxidation is probably not as great as under normal conditions, the [glucose] rises to levels comparable to those of well-fed animals (Stott). According to Heller and Moklowska ('30) the [glucose] of the blood of Lepidoptera rises during the pupal period. On the contrary, Kuwana ('37), who applied yeast fermentation, found that the sugar of the blood of the silkworm falls to zero at the beginning of metamorphosis and remains at zero during the pupal stage. The [glucose] of the blood of mature

TABLE 3

Carbohydrate and total reducing substances in the blood of arthropods

(Mgm./100 cc.)

| ARTHOPOD | TOTAL REDUCING SUBSTANCES (AS GLUCOSE) | "FREE" SUGAR (CALCU- LATED AS GLUCOSE) | GLY- COGEN | COMBINED OR PROTEIN SUGAR AND POLYSACCHARID LOWER THAN GLYCOGEN | INVESTIGATORS |
|---|---|--|---------------|--|---|
| Xiphosura: | | | | | |
| <i>Limulus polyphemus</i> | 11-22 | 11-22 | — | — | Dailey, Fremont-Smith, and Carroll ('32) |
| Crustacea: | | | | | |
| <i>Cancer productus</i> } | 90 | — | — | — | Myers ('20) |
| <i>C. antennarius</i> } | | | | | |
| <i>Maia squinado</i> | 20 | — | — | — | Drilhon ('33) |
| <i>M. squinado</i> (prior to molt)... | 185 | — | — | — | Drilhon |
| <i>Carcinus maenas</i> (starved 8 days)..... | 6 | — | — | — | Stott ('32) |
| <i>C. maenas</i> (fed)..... | 60± | — | — | — | Stott |
| <i>Palinurus argus</i> | 19-71 | — | — | — | Morgulis ('23) |
| <i>Cancer pagurus</i> | — | 10-30 | — | — | Roche and Dumazert ('35) |
| <i>Astacus fluviatilis</i> | 8-10 | 0-3 | — | — | Hemmingsen ('24) |
| Various decapods..... | — | 7-26 | — | — | Florkin ('36c, '37c) |
| Insecta: | | | | | |
| Grasshoppers: | | | | | |
| <i>Romalea microptera</i> (larva)... | 34.2-49.4 | — | — | — | Blumenthal ('27) |
| <i>Melanoplus femur-rubrum</i> ... | 30.6-41.9 | — | — | — | Blumenthal |
| <i>M. differentialis</i> | 31.0-45.9 | — | — | — | Blumenthal |
| <i>Chortophaga viridifasciata</i> ... | 34± | — | — | — | Blumenthal |
| <i>Encyrtolophus sordidus</i> | 36.4 | — | — | — | Blumenthal |
| Lepidoptera: | | | | | |
| <i>Phalera bucephala</i> (larva)... | 126.0 | 39.0 | — | — | Hemmingsen |
| <i>Deilephila euphorbiae</i> | 127.0 | — | — | — | Heller and Moklowska ('30) |
| <i>Prodenia eridania</i> (larva) | 65.9 | 11.1 | 3.29 | — | Babers ('38) |
| Various species (at differ- ent periods after feeding) | 58-450 | — | — | — | Hemmingsen |
| <i>Bombyx</i> (larva)..... | 24-43 | 0.4-4 | — | — | Kuwana ('37) |
| <i>Bombyx</i> (metamorphosing) | 24-50 | 0.0 | — | — | Kuwana |
| Hymenoptera: | | | | | |
| <i>Apis mellifica</i> (feeding larva) | 203± | — | — | — | Bishop, Briggs, and Ronconi ('25) |
| <i>A. mellifica</i> (spinning larva and pupa)..... | 775± | — | — | — | Bishop, Briggs, and Ronconi ('25) |
| <i>A. mellifica</i> (mature feeding larva)..... | — | 685 | 10> | 2,785-3,035 | Ronconi and Bishop ('28) |
| <i>A. mellifica</i> (prepupa)..... | — | 154 | 2,800 | 1,806 | Ronconi and Bishop ('28) |
| <i>A. mellifica</i> (pupa)..... | — | 20-80 | — | — | Ronconi and Bishop ('28) |
| Coleoptera: | | | | | |
| <i>Hydrophilus piceus</i> | — | 6-31 | — | — | Florkin ('37c) |

honeybee larvae is relatively great (Table 3) and declines to about 1/6 of its value during the prepupal and pupal periods. This decrease is accompanied by a lowering of the blood π . The blood sugar is thus vehemently drawn upon as a source of energy during spinning and metamorphosis. Also, at this time the cells of the fat-body begin to disintegrate and liberate large quantities of glycogen into the blood (Table 3), raising the glycogen of this fluid from an inappreciable quantity (i.e. < 10 mgm./100 cc.) to 2,800 mgm./100 cc. The blood of the larva and prepupa contains carbohydrate reserves in the form of protein-combined sugar and polysaccharid lower than glycogen (Table 3). These must be hydrolyzed to glucose, by carbohydrases in the blood, before they can be utilized by the cells. Ronzoni and Bishop have pointed out that the presence of complex carbohydrates in the blood, during the onset of metamorphosis, allows a more rapid utilization of carbohydrate than would be possible without a marked rise in the blood π which would follow a release of glucose from the tissues if glucose were the principal carbohydrate of the blood.

At the molting period the glycogen stored in the hepatopancreas of decapod Crustacea is broken down to glucose which is liberated into the blood. At this time, therefore, the [glucose] of the blood is extraordinarily high (Drilhon, '33a). The glucose is undoubtedly partly utilized in the formation of the chitin (a polymerized glucoseamine) of the newly forming skeleton (cf. Maluf, '37b).

Contrary to what happens in vertebrates, injected insulin has no effect on the rate at which sugar disappears from the blood of Lepidoptera and crayfish (Hemmingsen, '25) and even increases the total reducing power of the blood of such. No convulsions are produced. Insulin

does not exist in the glycogen-rich tissues of oysters (Long, '37). It is possible that, among invertebrates, other hormones take the place of insulin and adrenalin in evoking a liberation or storage of glucose according to the immediate demands of the animal.

(3) Lipids

The blood of the honeybee larva (feeding or spinning) contains about 453 mgm. of total fat per 100 cc. (Bishop, Briggs, and Ronzoni). At the time of metamorphosis, when the fat-body cells rupture and liberate their inclusions into the blood, the fat content of the latter rises enormously. The [cholesterol] of the blood of feeding honeybee larvae is 35 mgm./100 cc. (Bishop, Briggs, and Ronzoni) and 5.7 mgm./100 cc. of the blood of the crabs, *Cancer productus* and *C. antennarius* (Myers, '20). In comparison with mammalian blood the cholesterol value is much lower but the fat value is ordinarily higher.

(4) Proteins and free amino acids

While the [protein] of the blood is somewhat lower than that of mammals, the [free amino acid] of the blood of arthropods far exceeds that of the latter. The [amino acid] of the blood of insects is prodigious, being well above that of the Crustacea. It has already been pointed out that the amino acids account for the greatest component of the blood π of insects. The [amino acid] of the blood of the pupae is highest and is probably the result of proteolysis occurring during histolysis.

The plasma proteins act as buffers, tissue builders (especially during metamorphosis), agents of clotting, enzymes, and oxygen transporters.

(a) *The haemocyanins.* (i) *General.* The presence of a marked quantity of copper

TABLE 4

The protein and free amino-acid contents of the blood
(Mgm./100 cc. = protein or amino-acid nitrogen $\times 6.25$)

| ARTHEROPOD (ADULT UNLESS OTHERWISE SPECIFIED) | PROTEIN | FREE AMINO ACIDS | INVESTIGATORS |
|--|--|------------------|--|
| Lepidoptera: | | | |
| <i>Deilephila euphorbiae</i> (mature larva)..... | 5,156-ca. 6,000 | 1,062.5 | Heller and Moklowska ('30) |
| <i>Cossus cossus</i> (larva)..... | — | 14,040 | Duval, Portier, and Courtois ('28) |
| <i>Bombyx mori</i> (larva)..... | 2,760-5,165 (rises throughout larval life and decreases during beginning of metamorphosis) | — | Nazari ('02), Florkin ('37a) |
| <i>Attacus cynthia</i> (pupa)..... | — | 20,220 | Nazari |
| <i>Sphinx ligustri</i> (pupa)..... | — | 19,300 | Nazari |
| <i>Saturnia pyri</i> (pupa)..... | — | 17,100 | Nazari |
| <i>S. pyri</i> (larva)..... | 1,070-5,800 (rises throughout larval life) | — | Florkin ('35b) |
| <i>S. carpini</i> (pupa)..... | — | 21,000 | Nazari |
| <i>Prodenia eridania</i> (larva)..... | 1,044 | 1,469 | Babers ('38) |
| Coleoptera: | | | |
| Several species..... | 2,700-4,120 | — | Florkin ('35b) |
| <i>Hydrophilus pictus</i> | 3,400 | 7,000-8,800 | Nazari, Florkin ('37a) |
| <i>Dytiscus marginalis</i> | — | 8,400 | Nazari |
| Hymenoptera: | | | |
| <i>Apis mellifica</i> (larvae and pupa)..... | 6,656.25 | 1,812.5 | Bishop, Briggs, and Ronzoni ('25) |
| <i>Bombus agrorum</i> | 5,000-7,000 | — | Florkin ('37c) |
| Orthoptera: | | | |
| <i>Dixippus morosus</i> | 1,030 (lowest value in insects) | — | Florkin ('36a, '37c) |
| Arachnida: | | | |
| Black widow spider (plasma)..... | 3,000-5,000 (entirely haemocyanin) | — | Boyd ('37) |
| <i>Limulus polyphemus</i> (plasma)..... | 2,500 (practically entirely haemocyanin) | — | Dailey, Fremont-Smith, and Carroll ('31) |
| Decapoda: | | | |
| <i>Maia squinado</i> | 681-5,081 | 10 \pm | Delaunay ('13, '13a, '13b, '27) |
| <i>M. squinado</i> | 5,156 | — | Pora ('36) |
| <i>M. squinado</i> | 2,840-3,570 | — | Baglioni ('06) |
| <i>Cancer pagurus</i> | 5,669 | 41.87 | Pora |
| <i>Palinurus vulgaris</i> | — | 50 | Delaunay |
| <i>Cancer productus</i> | 2,125 | — | Myers ('20) |
| <i>C. antennarius</i> | — | — | — |

TABLE 4—*Concluded*

| ARTHROPOD (ADULT UNLESS OTHERWISE SPECIFIED) | PROTEIN | FREE AMINO ACIDS | INVESTIGATORS |
|---|-------------|---------------------------------|--------------------------------------|
| Decapoda:—<i>Concluded</i> | | | |
| <i>Carcinus maenas</i> | 4,000–4,200 | — | Drilhon-Courtois ('34) |
| <i>Astacus fluviatilis</i> | 5,668.7 | 41.9 | Delaunay |
| <i>A. fluviatilis</i> | 4,300 | 4.0 (only analyzed for tyrosin) | Pinhey ('30), Drilhon-Courtois ('34) |
| <i>Telphusa fluviatilis</i> | 1,200–3,800 | — | Drilhon-Courtois |
| <i>Pollicipes cornucopia</i> (cirrepede crustacean) | 200 | — | Florkin and Blum ('34) |

in the blood of crustaceans, cephalopods, and gasteropods was first noted by Harless (1846). In 1878, Fredericq concluded that the serum, but not the coagulum, of octopus blood contains a body which, when acted on by acids, splits up into a protein residue with no heavy metal and a substance containing copper. This body, which he found would reversibly turn blue on exposure to the air, he termed haemocyanin. Richet (1879) made the first quantitative measurement of the O_2 capacity of the blood of a haemocyanin-containing animal (a shrimp) but did not specifically hint the presence of an oxygen transporter. The presence of haemocyanin in the blood of Crustacea was established by Krukenberg (1880, 1880a, 1882). Pantin and Hogben ('25) and Hogben and Pinhey ('26, '27) have described a colorimetric method for studying the dissociation of haemocyanin which is suitable for classwork; and Osterhout ('18) has suggested the use of the aerated blood of *Limulus* as an indicator for measuring the relative rate of oxygen consumption of organisms. The occurrence of carotinoid pigments in the blood of several species often masks the blue of oxyhaemocyanin. Thus, the blood of the crab, *Maia verrucosa*, is red when first shed but changes to a deep bluish green when shaken with O_2 .

While the haemocyanin in the blood of a snail (Pantin and Hogben) is chiefly in the

oxy-form that in the blood of intact Crustacea (Pantin and Hogben) and of *Limulus* is almost entirely in the unoxxygenated condition. In fact, the oxygen concentration of the blood in the pericardial sinus of *Limulus* (Maluf, '37d) is even less than that of sea water of the same tonicity (see also Winterstein, '09, for *Maia*). The reason, however, that the gills of *Limulus* show no blue tinge is undoubtedly because the blood is in too thin a layer. In 1867, Paul Bert (cf. Redfield, '34) observed the change in color of the blood of cephalopod molluscs as it passed through the gills.

(ii) *Distribution of haemocyanin and the respiratory function of the blood of arthropods in general.* Haemocyanin occurs in the blood of various molluscs and, among arthropods, in the blood of certain decapod, notostracan, stomatopod, and amphipod Crustacea (cf. Redfield, '33; Florkin, '34), in *Limulus*, in spiders such as *Chaetopelma olivacea* (Wilson, '01; cf. Redfield, '34) and the black widow, *Latrodectus* (Boyd, '37), and in scorpions (Lankester, 1871; Svedberg and Hedenius, '33). It has been suggested that insects (Muttkowski, '21a, b) contain haemocyanin in their blood because the blood of crayfish, believed to contain haemocyanin and grasshoppers seemed to show Cu in approximately equal concentrations. No quantitative studies were, however,

made. "We have measured the concentration of copper in the blood of the Florida grasshopper and have found quantities so small that if it is present as haemocyanin the latter can have no importance in the transport of oxygen in the blood" (Redfield, '34). Babers ('38) has found that the total [Cu] in the blood of *Prodenia* larvae is only about 5 per cent and that that in the protein precipitate is as low as 1.99 per cent. From what has been said concerning the concentration of oxygen in the circulating blood it is evident that the haemocyanin in the blood of *Limulus* and *Maia* serves no significant respiratory function—at least under ordinary oxygen pressures. It is probable that haemocyanin, almost the only protein in *Limulus* blood plasma (Alsberg and Clark, '15; Montgomery, '30), in decapod serum (Halliburton, 1885), and in spider serum (Boyd, '37), acts mainly as a pH buffer. This is corroborated by the O₂ consumption—O₂ pressure curve of *Limulus*, which resembles that of the starfish, an animal with no oxygen transporter in its perivisceral fluid (Maluf, '37d).

Melvin ('31) analyzed the Cu content of whole insects and found that some insects accumulate Cu but all the information he gives us of the Cu content of the blood is that it is less than in certain tissues and waste products, i.e. less than 3.3 mgm./100 cc. Millot ('26) could detect no respiratory protein in the blood of certain spiders. Muttkowski nevertheless insisted that the blood of *Aeschna* (dragonfly) and *Dytiscus* (beetle) larvae must have some respiratory function since their blood reacted copiously with pyrogallol even after the animals had been under practically anaerobic conditions. But Bishop ('23) found that the oxygen capacity of the blood of honeybee larvae ranges between 0.2 and 0.8 vol. per cent, which he considers to be within

experimental error of the amount that can be freely dissolved at ordinary temperatures. The oxygen concentration of the blood of beetles and fly larvae (Barratt and Arnold, '11; Florkin, '34, '37a, d), collected under paraffin without exposure to air, is, in the words of the former, "too small to determine," and with the modern Van Slyke technique used by the latter, occurs only in traces (0.0–0.1 vol. per cent). Similarly, Babers ('38) has not been able to detect any O₂-combining power in the blood of the larva of the moth, *Prodenia*.

Astoundingly high figures for the oxygen concentration of the blood of decapod Crustacea and an insect have been given by Griffiths (1892). Thus the [O₂] of the blood of the crab, *Cancer pagurus*, was found to be about 14.8 vols. per cent; that of the crawfish, *Palinurus vulgaris*, about 14.5 vols. per cent (close to the older value of Richet, 1879); that of the lobster, *Homarus vulgaris*, about 14.8 vols. per cent, and that of the moth, *Acherontia atropos*, about 16.5 vols. per cent. According to Griffiths, therefore, the [O₂] of the blood of the moth is within the range of variation of the O₂ capacity of the haemoglobin-containing blood of mammals. Dhéré ('00, '03), Winterstein ('09), and Florkin ('37a, d) have shown that Griffiths' values are many times too high. Thus the O₂ capacity of the blood of haemocyanin-containing crabs and the lobster was about 1.4 vols. per cent. The O₂ capacity of the blood of *Limulus* (Redfield, Coolidge, and Hurd, '26; Alsberg and Clark, '14) varies considerably (0.43 to 2.14 vols. per cent), being, like the haemocyanin concentration, lower during starvation. The [O₂] of sea water at 25°C. and ordinary atmospheric pressure is ca. 0.50 vol. per cent.

(iii) *Constitution*. In all species examined (cf. Redfield, '34; Roche, '36) one

molecule of oxygen combines with a quantity of haemocyanin containing exactly 2 atoms of Cu. Within limits, the O₂ capacity of the blood varies directly with its Cu concentration (Dhéré, '03). Copper is the only heavy metal in haemocyanin since the evidence for zinc in *Limulus* haemocyanin is very probably due to impurities in the analytic vessels (Gatterer and Philippi, '33).

"Unpublished experiments made by Dr. Beecher . . . were also unsuccessful in demonstrating the presence of zinc in purified *Busycon* haemocyanin although this element could be detected in the whole blood . . . Conant, Dersch, and Mydans (personal communication) . . . suggest that the prosthetic group of *Limulus* haemocyanin is a complex copper salt of an unknown sulfur compound and a polypeptid consisting of one molecule each of leucine and tyrosine and three of serine" (Redfield *loc. cit.*).

Philippi ('19), however, noted an intense pyrrol reaction in *Helix* haemocyanin. For further data concerning the properties of haemocyanin the reviews of Dhéré ('28), Redfield ('34), Florkin ('34b), and Roche ('36), should be consulted.

The phylogenetic significance and apparent interrelationship of chlorophyll, haemoglobin, and haemocyanin are often considered to revolve around the essential pyrrol nucleus of the earlier pigment, chlorophyll (see, for instance, Moseley, 1877, and Gortner, '29).

The molecular weights of the haemocyanins are extraordinarily high. The molecular weight of *Limulus* haemocyanin is 1,300,000; of *Homarus americanus* is 640,000 (Svedberg in personal communication to Redfield, '34); of *Palinurus* is 446,000; of *Nephrops* is 820,000 (Eriksson-Quensel and Svedberg, '36; Svedberg, '37).

While the oxygen in haemoglobin is liberated by K₃Fe(CN)₆ (Barcroft, '14) and not by KCN (cf. Abderhalden, '11); that in haemocyanin is liberated by KCN (Kobert, '03; Redfield, Coolidge and

Hurd, '26; Pearson, '36) and not by K₃Fe(CN)₆ (Stedman and Stedman, '25); that in hemerythrin is liberated by both (Marrian, '27; Cook, '27-'28); and that in echinochrome by K₃Fe(CN)₆ but not by KCN (Cook, *loc. cit.*). The oxygen can, however, be easily liberated from haemocyanin by a vacuum, such as that created in the Van Slyke-Neill manometer.

The percentage dissociation—oxygen tension curve of oxyhaemocyanin into haemocyanin and molecular oxygen varies with various factors such as pH (Pantin and Hogben, '25; Hogben, '26; Stedman and Stedman, '26), temperature, salts, and the variety of haemocyanin. The affinity for O₂ varies inversely with temperature (Pantin and Hogben, '25; Hogben, '26; Redfield, Coolidge, and Hurd, '26) and thus a given animal will be more active but more susceptible to oxygen lack at a higher temperature (within limits) than at a lower. Since haemoglobin acts in the same way, the same applies to poikilothermic vertebrates. Similarly, since the haemocyanin of *Limulus* blood is relatively more saturated at low oxygen tensions than that of several other animals (e.g. the squid, *Loligo*) under identical conditions (Redfield, Coolidge, and Hurd, '26), the activity of *Limulus* is quite limited at low oxygen pressures while the activity of *Loligo* is maintained for a brief period at the expense of molecular oxygen, released by the rapidly dissociating haemocyanin, until asphyxiation results. For reasons already noted above, however, it is hardly likely that haemocyanin is of any marked significance in the respiratory exchange of *Limulus*.

Contrary to haemoglobin, the affinity of *Limulus* Hcy for CO is only 1/20 as great as for O₂ (Root, '34). Animals possessing Hcy as their respiratory protein would, from this alone, be expected to be

less susceptible to CO-poisoning than those which depend upon Hb for their oxygen supply.

(b) *Haemoglobin*. (i) *Distribution*. Svedberg and Eriksson-Quensel ('33) have pointed out that while "the red respiratory pigment of invertebrates closely resembles that of vertebrates with regard to its absorption spectrum and O₂-binding capacity (Barcroft, '24), these two properties are connected with the hemin group and not with the protein molecule." They remarked (see also Svedberg and Hedenius, '33, '33a, '34; Svedberg and Eriksson-Quensel, '34) that, like haemocyanin and chlorocruorin, the red respiratory pigment which occurs in invertebrates has, in most of the few cases studied, a molecular weight of the order of millions while all other proteins have proteins with molecular weights of a lower magnitude (35,000-200,000). They therefore suggested the use of the term erythrocrurorin for the entire red series, reserving the name haemoglobin for the variety which has a molecular weight of ca. 69,000, an isoelectric point at pH 6.7, and which is characteristic for the vertebrates with the exception of the Cyclostomata. Erythrocrurorin indeed has priority.

"Now in the article of 1868 where Ray Lankester proposed the term chlorocruorin for the green blood pigment of the polychaete worms he suggested the term erythrocrurorin for the red blood pigment of the invertebrates. In England the name cruorin at that time stood for respiratory blood pigment in general (suggested by Stokes 1864). In his next paper Ray Lankester (1870), however, abandoned the term erythrocrurorin and called the red blood pigments of the invertebrates hemoglobin, the latter name, suggested by Hoppe-Seyler in 1864, having in the meantime come into general use for the blood pigment of the invertebrates."

Until the protein moiety of the red respiratory pigment of invertebrates is shown to be other than a globin and in view of the undesirability of nurturing a

surplus of names in science, it appears that the term haemoglobin should be retained for the general group more especially since the molecular weight of the haemoglobin of the midge, *Chironomus plumosus* (Svedberg and Eriksson-Quensel, '34), is only ca. 31,400. That of *Daphnia* (Svedberg and Eriksson-Quensel, '34) is ca. 410,000. These are the only arthropods studied in this respect. The molecular weight of *Chironomus* haemoglobin is, within the limits of error, equal to a haemoglobin unit (= 34,500). If one believes that globins are characterised by a high histidin content (7 to 8 per cent) and by a deficiency in arginin (ca. 4 per cent) one might, in fairness to the term "erythrocrurorin," state that this pigment, where it has been analysed in invertebrates (*Lumbricus*, *Arenicola*, *Glycera*), has, according to Roche ('36), a high arginin content (ca. 10 per cent) and a deficient histidin content (ca. 4.5 per cent). But what about *Chironomus*?

Haemocyanin never occurs in corpuacles, always being suspended in the blood. The same applies to haemoglobin where it occurs in arthropod blood. In 1861, Rollet isolated haematin crystals from "red-colored larvae," living in rain-water swamps, and identified the red substance as haemoglobin. This is the first record of haemoglobin in arthropods. Within this group haemoglobin occurs in the blood of certain entomostracans (*Apus*, *Branchipus*, *Artemia*, *Daphnia*, *Chirocephalus*, *Lernanthropus*, *Clavella*, *Congericola*), in larvae of certain species of the midge, *Chironomus*, and culicoid Diptera (Lankester, 1868, '69, '70, '71, '72; Heider, 1879; van Beneden, 1880; Regnard and Blanchard, 1883, '83a; Harnisch, '25; Muttkowski, '21b; Verne, '23). For the further distribution of oxygen transporters in the blood of animals and for phylogenetic discussions the excellent works of

Sorby (1876), Barcroft ('25), Redfield ('33), Florkin ('34a, b), and Roche ('36) should be consulted.

In 1902, Vaney first demonstrated that the red material of the fat-body and "tracheal body" of larvae of the oestrid fly, *Gastrophilus equi* is haemoglobin. This was later confirmed by von Kemnitz ('16) who found that its haemoglobin differs in its absorption bands from that of the horse (in which the larva is an endoparasite) and thus concluded that the larvae synthesize their own haemoglobin. The haemoglobin of each species is characteristic; this would be expected when it is realized that proteins are species-specific.

(ii) *Formation*. Protohaematin, a precursor of haematin, and globins are found in the cells of all aerobic organisms (Keilin, '33). The arthropods containing haemoglobin dwell in the midst of decaying organic matter, where the oxygen pressure is necessarily low. Newly hatched larvae of *Chironomus gregarius* (Pause, '18) have a colorless haemolymph. Under natural conditions, the blood begins to turn red during the middle of the third instar. When the larvae are kept in oxygen-saturated water, however, haemoglobin appears later in larval life. It is evident that the oxygen pressure in the water has an influence on the time of haemoglobin formation in these larvae.

It is known that chlorophyll and iron favors the formation of haemoglobin in mammals. Comas ('27) found that chironomid larvae will produce an ample amount of haemoglobin even when bred to a length of one cm. without food or when fed on mushrooms and potatoes. Green algae and green leaves taken as food enhanced haemoglobin formation as compared with those fed on the comparatively iron-free diet. It is, however, impossible to conclude from this work that the

larvae can synthesize the tetrapyrrol nucleus of haemoglobin, for, there may exist a reserve of such in the egg. Furthermore, Verne ('23), by a similar technique, demonstrated that *Daphnia pulex* cannot synthesize haematin. While red pigment always appeared, it was, in the tests, exclusively the carotinoid, zooerythrin.

(iii) *Function*. Certain biologists, such as Miall (1898) and Pause ('18) have entertained the belief that, because haemoglobin-containing invertebrates live in oxygen-poor surroundings, their haemoglobin can store oxygen. In Krogh's laboratory Leitch ('16) showed that, as in vertebrates, the haemoglobin of *Chironomus* can act as a transporter but not as a store of oxygen. This is also true for other invertebrates possessing haemoglobin (Borden, '30-'31). In this respect it is significant that the haemoglobin of these animals releases its oxygen only at very low oxygen pressures (Leitch; Borden; Harnisch, '27, '36). Cole ('21) observed that *Chironomus* larvae live at the bottom of lakes which had been "shown," by Winkler's method, to contain no dissolved oxygen. Eggleton ('31), however, found that *Chironomus* larvae cannot live in water which had been deoxygenated by shaking with mud. Furthermore, *Chironomus* undergoes an O₂ debt during O₂ lack (Harnisch, '36). Since animals cannot store oxygen to any significant extent, it is necessary to reanalyze this water for oxygen by a more refined technique before supposing that the animals are capable of a true anaerobic metabolism (cf. Barcroft '34). *Chironomus gregarius* (Pause, *loc. cit.*) becomes photonegative and retires to the bottom coincidentally with the appearance of haemoglobin. Species of *Chironomus* which do not contain haemoglobin (e.g. *C. motator*) remain at the surface where there is more free oxygen (Miall).

(c) *Toxoproteins*. This is an arbitrary

group which, if taken in its broadest sense includes almost all proteins. The most potent poisons known are proteins. Thus, ricin from the castor bean is many times more toxic than HCN and has a great agglutinating and haemolyzing capacity. The bushmen of the Kalahari make arrow poison from water extracts of the larvae of *Diamphidia locusta* (Boehm, '23), the poisonous principle being a protein.

Several species of Orthoptera, Hemiptera, Coleoptera, Lepidoptera, and Hymenoptera (Cuénot, 1890; Lutz, 1895; Hollande, '11a, b, and '26; Rabaud, '22; Hingston, '27) eject blood, when touched suddenly. The blood emerges from a rupture in the cuticle. The fluid may be ejected to a distance of as much as two inches, as in certain Indian grasshopper larvae (Hingston), or merely form a drop on the surface of the insect, as in most cases. Certain skeletal muscles, especially those of the abdomen, contract and thus increase the blood pressure (Hollande, '26). The integument may rupture at points of least resistance, at certain pores, or at eversible vesicles, depending upon the species. This reflex bleeding, or so-called "autohaemorrhage," is of adaptive significance since insects smeared with the blood of blood-ejecting species become repugnant to their would-be predators (Lutz, 1895; Cuénot, 1896; Hollande, '11b; Rabaud, '22).

Hollande ('11b) has, however, pointed out that it is unnecessary to conclude that the emission of blood is a protection against *all* predators. Thus, the blood of the lepidopteron, *Leucoma salicis*, is, when injected, harmless to swallows and bats but deadly to lizards and frogs; that of coccinellid beetles is deadly to spiders, lizards, and sparrows but harmless to warblers. Furthermore, blood toxicity does not necessarily imply the possession of the capacity of reflex bleeding, for, the

blood of the crabs, *Maia squinado* and *Eupagurus prideauxii* (Cantacuzène, '12, '20), haemolyzes and agglutinates vertebrate erythrocytes. There are no apparent histological differences between the blood of blood-ejecting species and their relatives which do not emit blood (Hollande, '11a).

(d) *Antibodies*. The blood of the crab, *Carcinus maenas* (Lévy, '24), parasitized with the rhizocephalid crustacean, *Sacculina carcini* gives an accentuated precipitate with dilute alkali. The unparasitized crabs yield a lesser precipitate. *Eupagurus prideauxii*, which lives symbiotically on *Adamsia palliata* (Cantacuzène and Damboviceanu, '34), is the only decapod crustacean the serum of which is capable of forming a precipitate with the toxin of *A. palliata*. Glaser ('18) immunized a grasshopper, *Melanoplus femur-rubrum*, against *Bacillus poncei* (pathogenic to grasshoppers). The blood of the immunized insects soon caused an agglutination of the bacilli in large masses. "I never saw a better reaction with *Bacillus typhosus* and typhoid serum." Insects have a remarkable natural immunity towards most bacteria even though these may be pathogenic to warm-blooded animals. There are, however, a number of bacteria which are harmless to warm-blooded animals but extremely pathogenic to insects. Artificial immunity can, however, be acquired (Chorine, '31).

(e) *Enzymes*. (i) *Tyrosinase*. The blood of many arthropods, such as decapod Crustacea (Hardy, 1892; Pinhey, '30), the phasmid *Dixippus* (Toumanoff, '26), various Lepidoptera (Geyer, '13; Glaser, '18; Heller and Moklowska, '30), beetles (Barratt and Arnold, '11; Gortner, '11; Werner, '26; Schmalfuss and Barthmeyer, '30), silkmoths at all stages (Yamafuji, '33b), and oestrid flies (von Kemnitz) turns dark brown when exposed to the air and thus exhibits the presence

of tyrosinase and the benzol-ringed chromogen. On the other hand, the blood of cicadas (Gortner), of the moths *Malacosoma neustria* and *Lymantria monacha* (Geyer), and of certain spiders (Millot, '26) contains no tyrosinase. There is a sexual difference in the blood of silkworm larvae and pupae, that of the males darkening more rapidly upon exposure to the air (Geyer).

Toumanoff (*loc. cit.*) concluded that the tyrosinase of *Dixippus* is liberated into the blood after the completion of development since all the internal organs yielded negative results. Such a hypothesis is unnecessary especially since Hardy (1892) seems to have demonstrated that tyrosinase is not freely suspended in the blood of the crayfish but is liberated into such when the corpuscles burst, as when the blood comes into contact with the air. These corpuscles are not present in the blood of *Limulus* and arachnids (Pinhey, '30) and the blood of such does not darken even upon the addition of tyrosine. Schmalfuss and Barthmeyer, working with insects, considered that the darkening is due to a loss of CO₂ and thus to an increased alkalinity, which favors the activity of tyrosinase. This does not take into account the fact that the blood of marine arthropods is alkaline. Barratt and Arnold wrote that "since the blood [of insects] darkened on exposure to air, or rather to oxygen, it follows that it contained exceedingly little dissolved oxygen in the straw-yellow condition which it exhibited in the living body." This, too, does not take into consideration the fact that the circulating blood of many crustaceans has oxygen in appreciable quantities—almost as much as in sea water (see above). Parenthetically, it may be stated that the optimum temperature and pH for the activity of tyrosinase of *Bombyx* blood (Yamafugi, '33) is pH 6.6 and 37°C.

(ii) *Other oxidases.* The blood of various insects contains peroxidase (Muttikowski, '21a; von Kemnitz, '16), and catalase (von Kemnitz; Yamafugi, '33b); that of spiders has no catalase (Millot, '26). The blood of silkmooths contains phenolase, peroxidase, and catalase (Yamafugi, '33b, '34; Yamafugi and Goto, '36).

(iii) *Hydrolyzing enzymes.* Various species of lepidopterous larvae contain amylase, maltase, proteinase but no lactase, cellulase, or lipase in their blood (Dirks, '22). Amylase occurs in the blood of honeybee larvae but not in the salivary glands or gut of the same (Bishop, '23; Bertholf, '27). The blood of larvae of the fly, *Gastrophilus* (von Kemnitz), has lipase, very active amylase and proteinase; that of the crab, *Maia*, and the lobster, *Homarus*, digests starch, sucrose, fat, and fibrin (Heim, 1892; Sellier, '02, '04); that of silkmooths (Yamafugi, '33a; '34a, b, c) has lipase, proteinase, amylase, sucrase, and maltase. Such enzymes are probably of paramount importance during metamorphosis when they would act on fats, glycogen, and proteins discharged into the blood by the disintegrating tissues and fat-body. In this connection, it is noteworthy that the activity of all the known blood enzymes of the silkmooth (Yamafugi), except catalase and lipase, is greatest at the beginning of metamorphosis, declines during pupal life, and rises in the adult. The proteinases are probably also of importance in the synthesis of blood proteins.

(5) *Carotinoids and carotinoproteins*

These pigments are transported by the blood and impregnate the hypodermal cells of many arthropods (Herrick, 1895; Keeble and Gamble, '04; Grandmougin, '12; Verne, '20a, '20b, '21, '23; Palmer and Knight, '24; Lwoff, '27; Abeloos and Toumanoff, '26; Toumanoff, '28; Fabré

and Lederer, '33; Brown, '34). The various bluish to reddish pigments of undescribed constitution noted in the blood of arthropods (Lund and Schulz, '30; von Siebold, 1848; Grube, 1859; Klunzinger, 1864; Gerstaecker, 1879; Hei-

1885a; Palmer and Knight, '24; Jucci, '30). The yellow carotinoid (xanthophyll) of the blood of silkworms is derived from the food and forms the yellow color of the cocoon, being absorbed by the silk glands (cf. Maluf, '38b). No animal

TABLE 5
Nitrogenous products of protein degradation
(Mgm./100 cc.)

| ARTHROPOD | UREA | PURINES (TOTAL) | URIC ACID | CREAT- ININ | NH ₃ | UREA + NH ₃ | OTHER NON- PROTEIN N | INVESTIGATORS |
|---|-------|--------------------|--------------|----------------|-----------------|---------------------------|-------------------------------|---|
| Insects: | | | | | | | | |
| Honeybee (larva)..... | — | — | 5.3 | 1.1 | — | traces | 41.6 | Bishop, Briggs, and Ronzoni ('25) |
| <i>Hydrophilus piceus</i> | 7.4 | — | 8-15 | — | — | — | — | Florkin ('37a) |
| <i>Bombyx mori</i> (larva).... | — | — | 10-14 | — | — | — | — | Jucci and Deiana ('30), Florkin ('37a) |
| <i>Prodenia eridania</i> (larva). | 6.2 | — | 14.8 | 8.0 | — | — | — | Babers ('38) |
| <i>Deilephila euphorbiae</i> (larva)..... | 20 | — | — | — | — | — | — | Heller and Moklowska ('30) |
| <i>Dixippus morosus</i> | — | — | 10.4 | — | — | — | — | Florkin ('37c) |
| <i>Dytiscus</i> (carnivorous)... | — | — | 17.97 | — | — | — | — | Florkin ('37c) |
| Several arthropods (names not stated)..... | — | — | — | none | — | — | — | Morgulis ('23) |
| Decapods: | | | | | | | | |
| <i>Palinurus vulgaris</i> | 6.56 | — | — | — | — | — | — | Sanzo ('07) |
| <i>P. argus</i> | 12-22 | — | 0.9-6.0 | none | — | — | 9-17 | Sanzo |
| <i>P. vulgaris</i> | 3.38 | 0.30 | 0.24 | — | 0.88 | 2.68 | 6.0 | Delaunay ('13, '13a, '13b, '27) |
| <i>Cancer productus</i> }..... | 5.15 | — | 4.7 | 0.78 | 1.15 | 6.3 | — | Myers ('20) |
| <i>C. antennarius</i> } | | | | | | | | |
| <i>Maia squinado</i> | 2.90 | 3.6 | 0.18 | — | 1.74 | 4.64 | 5.06 | Delaunay |
| <i>M. squinado</i> | — | — | 10.95 | — | — | — | — | Boivin ('29) |
| <i>M. squinado</i> | 3.83 | — | — | — | — | — | — | Sanzo |
| <i>Cancer pagurus</i> }..... | 1.8 | 0.30 | 0.24 | — | 0.88 | 2.68 | 6.0 | Delaunay |
| <i>Astacus fluviatilis</i> } | | | | | | | | |
| <i>Portunus corrugatus</i> | 3.68 | — | — | — | — | — | — | Sanzo |

der, 1879; de Mierzejewski, 1882; Cuénot, 1891, 1894; Müller, 1894; Gruvel, 1894; Dawson, '34) are chiefly "lipochromes," i.e. carotinoids or carotinoproteins (Jolyet and Regnard, 1877; Fredericq, 1879; Newbigin, 1879; Krukenberg, 1880-2; MacMunn, 1883, 1883a; Halliburton, 1885,

has as yet been ascertained to be capable of synthesizing a carotinoid compound. The blood of insects (Muttkowski, '23) may be colorless (e.g. *Calliphora*), yellowish (e.g. *Hydrophilus*), orange (e.g. *Leptinotarsa* larvae), orange-red to red (e.g. certain ephemerids), bluish (e.g. *Pro-*

tenthus larvae—Diptera), blue-green and green (e.g. *Anax* and *Aeschna* larvae); that of the Tardigrada (Shipley, '09) and Pycnogonida (Thompson, '09) is colorless.

(6) Nitrogenous wastes

Non-volatile nitrogenous wastes (Table 5) must be transported by the blood to the excretory organs in order to be eliminated. In the terrestrial forms, such as the insects, mites, and ticks, the bulk of the nitrogenous wastes is excreted in the form of uric acid which probably exists in the blood in the form of neutral dibasic urates. The carnivorous insects apparently have a higher [uric acid] in their blood than the herbivorous insects. The blood of Crustacea contains considerable quantities of urea. This is found only in traces in the blood of insects, with the possible exception of the moth, *Deilephila euphorbiae*. Approximately half or more of the non-protein nitrogen in the blood of arthropods is of unknown constitution and may probably be in the form of trimethylamine. Both Myers, in crabs, and Bishop, Briggs, and Ronzoni, in the honeybee larva, have found the creatinin concentration of the blood (Jaffé reaction) to approximate that of man. This is remarkable since, in the former, the hydrolysis of phosphoarginin seems to take the place of phosphocreatin during muscular contraction even though Meyerhof ('28) found phosphoarginin and phosphocreatin in approximately equal amounts in muscles of the crayfish. Morgulis nevertheless wrote that "it can be stated definitely with the support of an extensive number of analyses that creatinin is never present in the blood of arthropods." He did not, however, specify which arthropods. The creatin concentration of the blood of honeybee larvae is 2.0 mgm. (Bishop, Briggs, and Ronzoni) and that of *Cancer* is 0.58 mg. (Myers), both values being

somewhat less than the range in man (= ca. 3-7 mgm. per 100 cc.).

(7) Alkaloids

When the larvae of the butterfly, *Tortrix viridana* (Hollande, '23), feed on leaves of the oak, *Quercus sessiliflora*, epithelial cells of the mid-gut become replete with alkaloidal (probably tannin) crystals in their vacuoles. In rare cases their blood yields a positive reaction for alkaloids.

SUMMARY

1. The blood cells are involved in phagocytosis and clotting.
2. Clotting among arthropods often involves protein coagulation and an agglutination of blood cells. Both processes are possibly independent of each other. In many species the blood does not clot at all.
3. Clotting in most arthropods is probably evoked by a liberation of thrombin into the haemolymph as a consequence of the rupture of certain blood cells.
4. The blood of terrestrial arthropods is generally on the acid side of neutrality while that of certain marine arthropods (decapods) is known to be on the alkaline side of neutrality.
5. The acid-base balance is regulated by blood carbonates, phosphates, proteins, amino acids, the excretory organs, carbonic anhydrase (?), and, in fairly sized tracheate forms, to a slight extent by haemocyanin.
6. Most of the osmotic pressure of the blood of Crustacea and *Limulus* is accounted for by the [mineral] of the blood. In insects (terrestrial forms) the amino acids form the greatest component of the osmotic pressure of the blood. The concentration of amino acids in the blood of insects is extraordinarily great.
7. The osmotic pressure of the blood of most freshwater and terrestrial species is

lower than that of marine forms and approximates that of mammals.

8. Arthropods, in postembryonic stages, can invade fresh water if their integument is wholly impermeable to salts from interior to exterior and, in forms in which a portion of the integument is permeable to water (e.g. the gill filaments of crayfish and *Aedes* mosquito larvae), if excretion of a copious and very hypotonic urine occurs. The inevitable loss of salts with the hypotonic urine may be replenished by the ingestion of salts with the food or by the secretion, by the skin, of salts from the external hypotonic medium into the blood against an osmotic force.

9. Arthropods, such as certain mosquito larvae, which can breed just as well in fresh water as in strong brine, can do so possibly by virtue of an integument that is impermeable to water and salts in both directions.

10. The decrease in the blood π of certain marine decapods, which follows the rise (of unknown origin) of this just prior to molting, can be explained solely on a dilution basis. The intake of water aids ecdysis and the expansion of the new integument.

11. With respect to their condition in hypotonic media, marine arthropods exhibit graded differences depending upon the extent of the permeability of their integument and their capacity to secrete salts from the exterior into their blood.

12. The osmotic effects of drying are the same as those of hypertonic media.

13. The blood of most marine Crustacea

is more or less isotonic with the external medium but the proportions of the various minerals are not the same in both media. This is, in part at least, due to selective secretion of minerals by the kidneys.

14. The blood of insects is relatively poor in minerals and the latter deviate greatly, in their relative concentrations, from the condition in sea water.

15. As far as the evidence goes, the blood of arthropods with a well developed tracheal system contains no respiratory protein or other oxygen-combining substance.

16. Like haemocyanin, haemoglobin, where it occurs among arthropods, never exists in corpuscles but is always freely suspended in the haemolymph.

17. The haemoglobin is of no practical oxygen-storage significance but, since it dissociates only at very low oxygen pressures, is of importance in oxygen-poor media.

18. Certain insects eject blood over themselves which contains toxoproteins, thus protecting themselves against certain predators.

19. The hydrolytic enzymes freely present in the blood are probably of importance during metamorphosis and in the manufacture of blood proteins, glycogen, and fats.

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ADOLESCENT STERILITY (*Concluded*)

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THE HUMAN SPECIES

SCHULTZ and Snyder (114) remarked in 1935 that "Conclusive evidence of adolescent sterility in man is difficult to obtain" (p. 198). This, unfortunately, is true, and it is for this reason, among others, that the present paper has been written, in the hope that those who enjoy the requisite opportunities may be persuaded to undertake the search for the "conclusive evidence." In what follows the evidence may be evaluated in terms of probability alone. "Conclusive evidence" is evidence to which so high a degree of probability attaches that there can be little or no doubt that it represents a true description of conditions. None of the evidence relating to the human species which is here examined possesses anything like so high a degree of probability that it may be taken as a perfectly true description of conditions. Exactly what the degree of probability here is the reader may have an opportunity of determining for himself.

Historically, the subject of adolescent sterility is not altogether without interest. In the writings of the great Hindu physician Suśruta, who flourished some five centuries before the Christian Era, there occurs the following remarkable passage: "If a man under twenty-five deposit his germ (*garbha*) in a woman younger than sixteen, it will (most likely) die in the womb. Even if it be born alive it will

either soon die, or he will be imbecile and weakly so long as he lives" (125).

Plato not being either a physician or a biologist has nothing more pertinent to offer than the following passage, which occurs in *The Republic* (99):

A woman . . . may begin to bear children to the State at twenty years of age, and continue to bear until forty; a man may begin at five-and-twenty, when he has passed the point of life at which the pulse of life beats quickest, and continue to beget children until he be fifty-five.

Certainly . . . both in men and women those years are the prime of physical as well as of intellectual vigour.

In the *Politics* Aristotle (5) writes:

"Since the legislator should begin by considering how the frames of the children whom he is rearing may be as good as possible, his first care will be about marriage—at what age should his citizens marry? . . . The union of male and female when too young is bad for the procreation of children; in all other animals the offspring of the young are small and ill-developed, and with a tendency to produce female children, and therefore also in man, as is proved by the fact that in those cities in which men and women are accustomed to marry young, the people are small and weak; in childbirth also younger women suffer more, and more of them die; some persons say that this was the meaning of the response once given to the Trocians—the oracle really meant that many died because they married too young; it had nothing to do with the ingathering of the harvest. It also conduces to temperance not to marry too soon; for women who marry early are apt to be wanton; and in men too the bodily frame is stunted if they marry while the seed is growing (for there is a time when the growth of the seed, also, ceases, or continues to but a slight extent). Women should marry when they are about

eighteen years of age, and men at seven and thirty; then they are in the prime of life."

Matthews Duncan (30) writing in 1866 suggested that: "In the case of some peoples, facts might be collected regarding wives so young as to be in a large proportion sterile from immaturity; and their fecundity gradually appearing as age advanced, might produce a column of mothers from ten to twenty years of age, showing a gradually increasing fecundity of the population at these ages" (p. 24).

Before turning to an examination of the evidence which Duncan himself presented in his great book, we may here note what, after a very careful search, proved to be the earliest discoverable recognition of the phenomenon of adolescent sterility in man. This is by Renaudin (105), and occurs in his article "Nubilité" in the great *Dictionnaire des Sciences Médicales* of 1819.

Renaudin writes:

NUBILITY, *s. f.*, *nubilitas*, the aptitude for marriage.

Nubility is not to be confused with puberty; the latter has a slow or a rapid beginning and development which coincides with the last efforts of general growth: the former assumes this growth terminated and all the organs having reached the degree of perfection and power necessary to permit man to procreate his kind, and woman to bear the fatigues of pregnancy, childbirth and its aftermaths.

This is beautifully clear; yet in the same work Maygrier (74) writing on menstruation equates the first appearance of the latter with the capacity to procreate. It is not until more than a quarter of a century later that we obtain a statement concerning the phenomenon based on detailed observations which are carefully reported; this is by J. M. Waddy (132).

Waddy carried out his inquiries among the factory hands of the district of Birmingham in England, and the following

are his observations on the "age at commencement of menstruation":

"Of 623 females, in one the catamenia occurred at nine years of age; 2 menstruated at ten; 15 at eleven; 46 at twelve; 87 at thirteen; 130 at fourteen; 115 at fifteen; 105 at sixteen; 67 at seventeen; 43 at eighteen; 10 at nineteen; and two at twenty" (p. 674).

Waddy goes on to add that:

"Out of 628 females, we find marriage took place in upwards of 500 persons previous to the twenty-fourth year of their age. Yet few pregnancies took place before that period. The greatest number of pregnancies range from the twenty-fourth to the thirty-fourth year of age. The largest number of marriages are at the nineteenth and twentieth years; and yet only six individuals were pregnant at nineteen years old, and only twenty-seven at twenty. Surely these facts show that the powers of procreation are feeble in the female of tender years; and where Nature indicates a fact, we do well to attend to her instruction" (p. 675).

This is splendid for 1846.

In 1860 the French gynecologist Dubois (28) in discussing nubility writes as follows:

"When this aptitude is developed and when the genital functions may be exercised in woman, without probable prejudice to herself or to her offspring, she is considered nubile.

"Thus understood, nubility not only implies the abstract faculty of procreating, but the possibility of a procreation not injurious to the mother or to the infant.

"Nubility results from the necessary accomplishment of two orders of modifications: the one is local and is produced in the organs of generation, the other is general and affects the whole economy.

"The manifestation of the first, which is also the more important, has for its consequence, puberty, which it is necessary to take care not to confuse, as several authors have done, with nubility, of which it is only one of the essential conditions.

"I wish thus to give their true meaning to two expressions, too often employed as if they had the same signification. The word nubility implies the idea of an aptitude, puberty implies that of a condition which favours or renders possible the exercise of this aptitude. A girl to be nubile must first have puberty. But when she has puberty, it does not

follow that she is nubile, because puberty is not the only condition necessary for nubility. The ancients made no confusion in this matter. *Puberty*, from *pubes*, hair, indicated the age when certain parts began to be covered with hair. *Nubility*, from *nubis*, a cloud, veil and from its derivative, *nubilis*, indicated the age when the young girl was in a state to wear the nuptial veil, that is to say, to be married" (p. 269).

Our next observation relating to these matters is from the magnificent gynecological treatise written in 1867 by Joulin (64). Joulin writes:

"Nubility is the complement of puberty. These two states should not be confused; they rarely develop at the same time, and their appearance is ordinarily separated by an interval of several years. Puberty is the age at which the young girl becomes a woman; nubility is the period when she becomes capable of all the requirements of maternity. It is frequent, in our latitudes, to see the menses appearing at eleven or twelve years; pregnancy will strictly speaking be possible, but assuming that the young mother has escaped the dangers of a labour so difficult for her, will she be able to nourish her infant, and give it the necessary care? Is she capable of understanding the full extent of her duties and meeting all the difficulties? No, for nubility has not yet arrived, and it is then only that the complete development of the organs, of the bodily powers, and of the intelligence will permit her to fulfill this task adequately. The Civil Code authorises matrimonial union when the woman is fifteen years old and the man eighteen; but civil law is not in accordance with physiological law, and the race which permits such premature unions will not be long in degenerating. No general limit should be fixed, as is done, for nubility; were this limit fixed at 18, 20, or 22 years, numerous deviations from the common level would occur.

"When I am consulted as to the desirability of marriage for very young individuals, I customarily reply to the parents: that they should not permit their daughter to marry, that is to say, expose her to the risk of becoming a mother until a year at least has elapsed after her stature has ceased to increase. This is the period which I fix upon as nubility; embonpoint, size may add to the volume of organs, but Nature will add nothing to their development" (pp. 103-104).

A few months later, in 1866/67, we find Matthews Duncan (29) writing:

"It is, I believe, a common notion that the occurrence of menstruation indicates the arrival of the nubile age. Authors occasionally use such expressions as—advent of nubility and commencement of menstruation—as synonymous. The age of puberty may be contemporaneous with the age of nubility; but it cannot be assumed to be so without proof, for very little reflection will suggest to the physiologist many reasons for supposing that the marriageable age is generally delayed for several years after the arrival of the age of puberty" (pp. 207-214).

In corroboration of this point of view Duncan then quotes the passage from Joulin given above. He then goes on to discuss the dangers of early maternity, and quotes two breeders as saying

"that the mortality of the young of these animals [lambs and calves], when the mothers are immature, is much greater than when they are well grown. . . . One of them says, 'Taking the first lamb from ewes at one year old has in almost every case failed to be remunerative, owing to the frequent deaths of the lambs. The same may be said of young heifers though the mortality of the offspring may not be so marked as in that of sheep'" (p. 212-213).

"In conclusion, it is almost useless to add that I consider the age of about from 20 to 25 the nubile age of woman. The numerous facts and arguments I have adduced, appear to me to bear out distinctly this conclusion. Below 20 years of age, woman is immature, she runs considerable risk of proving sterile, and if she does bear a child she runs a comparatively high risk of dying in childbed; besides, her early marriage brings many other disadvantages. . . . The woman above 25 years of age is mature, but to counterbalance this, she encounters some greater risks than the very young wife's though of a similar nature" (p. 214).

In his book published in 1866 Duncan (30) reprinted the article from which these passages have been taken together with some additions as Part VIII (pp. 277 sqq.).

Duncan, who carried out most of his investigations during the fifties and sixties of the last century, has made available a large amount of data relating chiefly to Scottish women of the laboring classes, data of the greatest interest in our present

connexion. In Table 4, for example, the ability of women marrying at different ages to bear children within the first year of married life is clearly described.

From Table 4 it is evident that women of the 15-19 year group are less fecund within the first year of marriage than women of the presumed mature group of 20-24 years. In the 25-29 year group, the ability to conceive within the first year is already less than in the 15-19 year group, and steadily declines with age.

When the conditions for the first two years of marriage are considered these startling inequalities are for the most part removed, as is shown in Table 5.

What this tremendous increase in fecundity in the second year of marriage over the first year of marriage, reflected in Table 5, means it would be difficult to say and foolhardy to suggest here. What is of significance for us here is that in the second year of marriage six times as many women conceived within the 20-34 year

TABLE 4

*Initial fecundity of women of different ages within the first year of marriage**

| AGES OF WIVES NEWLY MARRIED..... | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 |
|-------------------------------------|-------|-------|-------|-------|-------|-------|
| Number of wives newly married..... | 700 | 1,835 | 1,120 | 402 | 205 | 110 |
| Wives-mothers within 1st year..... | 96 | 339 | 139 | 46 | 19 | 4 |
| Percentage of latter to former..... | 13.71 | 18.48 | 12.41 | 11.44 | 9.27 | 3.63 |

* After Duncan, Tab. 9 (the complete table is not reproduced).

TABLE 5

*Initial fecundity of women of different ages within the first two years of marriage**

| AGES OF WIVES NEWLY MARRIED..... | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 |
|--|-------|-------|-------|-------|-------|-------|
| Number of wives newly married..... | 700 | 1,835 | 1,120 | 402 | 205 | 110 |
| Wives-mothers within 2 years of marriage.. | 306 | 1,661 | 849 | 253 | 84 | 17 |
| Percentage of latter to former..... | 43.71 | 90.51 | 75.80 | 62.93 | 40.97 | 15.45 |

Increase in fecundity over the first year

| | | | | | | |
|--|-------|-------|-------|-------|-------|-------|
| | 30.00 | 72.03 | 63.39 | 51.49 | 31.70 | 11.82 |
|--|-------|-------|-------|-------|-------|-------|

* After Duncan, Tab. 10 (the complete table is not reproduced).

It must be clearly borne in mind that this table tells us no more than that *the ability to conceive within the first year of marriage* is greatest in the young mature group, less in the immature group, and increasingly smaller in the older groups. We may legitimately assume that this difference in first year fertility in the immature and older groups is due to different factors; in the immature group being due to incomplete sexual development, and in the older mature groups to factors which can at present only be guessed at.

groups as were able to conceive within the first year of marriage, and more than four times as many in the 35-44 year groups; whereas in the relatively immature 15-19 year group scarcely more than three times as many were able to conceive in the second year than in the first year of marriage. Thus, the relative infecundity of the 15-19 year group is here interestingly illustrated.

If now we examine the data for the women of under 20 years of age by means of annual instead of quadrennial incre-

ments we shall obtain a clearer view of the initial fecundity of these women during the first and second year of marriage.

From Table 6 we may gather that in the first year of marriage the Scottish women of 16 years of age investigated by Duncan were found to have become mothers in only 6.45 per cent of cases; at 17 years of age fecundity is increased by about one-fifth; at 18 years of age almost twice as much as at 17, and two-and-a-quarter times as much as at 16 years of age; and at 19 the increase over the preceding age is one-fourth again as great as

marriage than those of the 18 and 19 year groups. Brides of all four groups showed in a marked degree an inability to conceive in the first year of marriage, though this inability was most marked in the youngest group, becoming increasingly less marked with the advance to the 19 year group. Thus, it is seen that the more mature groups exhibit a greater ability to overcome this initial infecundity than the younger groups.

It is perfectly legitimate to assume that the conditions of nutrition, occupation, climate, fertility of husbands, method of

TABLE 6

*Initial fecundity of women under 20 years of age in the 1st and 2nd years of marriage**

| AGE OF WIVES NEWLY MARRIED..... | 16 | 17 | 18 | 19 |
|---|-------|-------|-------|-------|
| Number of wives newly married..... | 43 | 108 | 225 | 314 |
| Wives-mothers in 1st year of marriage..... | 2 | 7 | 31 | 56 |
| Corrected per cent**..... | 6.45 | 7.77 | 14.70 | 18.30 |
| Wives-mothers within two years of marriage... | 4 | 27 | 98 | 177 |
| Corrected per cent**..... | 12.90 | 30.00 | 46.44 | 57.84 |

* After Duncan, Tables 11 and 12 combined.

** Note: By corrected per cent is meant that a correction has been made to allow for the fact that some of the young brides may not yet have commenced menstruating at the time of marriage. This correction tends to lessen the contrast between the fecundity figures of say, the 16 and 20 year groups. It is possible that this correction was not necessary; it doesn't seem very likely that girls would marry had they not commenced menstruating. At least this would not be the case among Scottish girls, upon whom these figures are based.

at 18, and almost three times as great as at 16.

A similar lag in fecundity in the 16 year old women is noticeable in the second year of marriage, for whereas in the 17 year old brides fecundity has increased by four times over the first year of marriage, $3\frac{1}{4}$ times in the 18 year old group, and $3\frac{1}{2}$ times in the 19 year old group, the increase in the 16 year old group has only been twice as much.

From such evidence we conclude that the Scottish brides investigated by Duncan some eighty years ago at the ages of 16 and 17 years were significantly less able to conceive within the first year of

intercourse, and contraception, were much the same in these several age groups; it would seem very unlikely from Duncan's account that any kind of contraception was ever practised. Hence, as far as they go, these data may be accepted as indicative of the fact that immature women, here arbitrarily placed in the 15-19 year group, are less frequently able to conceive than mature women, here arbitrarily placed in the 20-35 year group.

These conclusions are fully corroborated by the findings on Indian women reported in 1931 by Pillai (97) for the province of Travancore, and in 1939 by Pearl (96) for American Women.

Duncan's data would indicate that the maximum degree of fecundity is reached at 23 years, before which the capacity is in process of development, and continues until 27 years, whenafter it steadily declines.

Another table from Duncan on a different series of women may be cited here as of interest in our present connexion.

Table 7 illustrates once more, in a totally different series of women, the relative infertility of wives under 20 years of age as compared with the mature women.

Harris (48) made the following pertinent remarks in the same connexion in 1873:

The incipency of menstruation in our large cities, as a general rule, marks only the gradual approach of the nubile period, and occurs before there are very decided evidences of womanly development, especially in the maturity of the pelvic diameters; so that the possibility of conception is still quite remote. Pelvic expansion, which appears to have been general in cases of early pregnancy at any age, enabling the subjects of it to bring forth living children of full or nearly full size, is evidently only in its incipency in a large number of young menstruous girls.

TABLE 7
*The variation in sterility according to the ages of wives in Providence**

| AGES OF BRIDES..... | UNDER 20 | 20-25 | 25-30 | 30-40 | 40-50 | TOTAL |
|-----------------------|----------|-------|-------|-------|-------|-------|
| Number..... | 144 | 366 | 161 | 108 | 22 | 801 |
| First children..... | 49 | 215 | 113 | 45 | 2 | 424 |
| Sterile..... | 95 | 151 | 48 | 63 | 20 | 377 |
| Per cent sterile..... | 65.97 | 41.25 | 29.8 | 58.3 | 90.9 | 47.06 |

* After Duncan, Tab. 71 (2nd Ed. 1871, p. 201, 30b).

TABLE 8
*The interval between marriage and birth of first child in wives married at different ages**

| MOTHER'S AGE AT MARRIAGE..... | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 |
|--|-------|-------|-------|-------|-------|
| Number of mothers..... | 649 | 1905 | 809 | 251 | 96 |
| Average interval from marriage to 1st child-birth (in mos.)..... | 18.2 | 15.9 | 16.2 | 18.1 | 19.1 |

* After Duncan, Tab. 38 (condensed).

A final table from Duncan further illumines the points we have here been discussing.

Initial infecundity is, from Table 8, again seen to be overcome earlier in the mature groups from 20-34 than in the immature 15-19 year group. The relatively greater initial infecundity of the older group between 35 and 39 may be explained as due to factors quite different from those operating in the case of the immature group; in the latter case we must posit immaturity and all that that implies; in the former case, perhaps the beginning of an involutionary process.

The *preparatory period*, which usually exists between the first appearance of the menses and the age of possible conception, varies from a few months to several years; but there have been instances in which impregnation followed the first menstrual epoch, or even took place before it has appeared. In tropical countries where young menstrual girls are given in marriage, impregnation very rarely takes place until some time has elapsed, thus marking the duration of this period of sexual preparation.

Mikulicz-Radecki and Kausch (78), in an investigation carried out in the Woman's Clinic of the University of Berlin, reported in 1935 that in 74 cases where first sexual intercourse occurred in post-menarchial girls between the ages of 13

TABLE 9

Changes in median pregnancy and live-birth rates (per 100 computed ovolutions) with advancing age. White multiparae, married once only, living in wedlock, and free of gynecologic disease, married in age group 15-19 and thereafter continuously exposed to risk of conception through age period when observed. None made any contraceptive effort at any time

A. MEDIAN RATES

| GROUP | N | MEDIAN RATES IN INDICATED AGE PERIODS | | | | |
|--|-----|---------------------------------------|-----------------|-----------------|-----------------|-----------------|
| | | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 |
| 40 years old and over at observation: | | | | | | |
| Pregnancy rates..... | 63 | 2.25 \pm 0.59 | 6.83 \pm 0.37 | 4.78 \pm 0.37 | 4.43 \pm 0.44 | 4.17 \pm 0.56 |
| Live-birth rates..... | 63 | 2.08 \pm 0.57 | 4.90 \pm 0.37 | 4.56 \pm 0.30 | 4.31 \pm 0.37 | 4.03 \pm 0.46 |
| 35-39 years old at observation: | | | | | | |
| Pregnancy rates..... | 169 | 2.54 \pm 0.41 | 4.88 \pm 0.29 | 4.49 \pm 0.29 | 4.21 \pm 0.27 | .. |
| Live-birth rates..... | 169 | 2.27 \pm 0.41 | 4.74 \pm 0.25 | 4.38 \pm 0.25 | 4.03 \pm 0.26 | .. |
| 30-34 years old at observation: | | | | | | |
| Pregnancy rates..... | 242 | 2.75 \pm 0.40 | 4.68 \pm 0.23 | 4.42 \pm 0.21 | .. | .. |
| Live-birth rates..... | 242 | 2.33 \pm 0.39 | 4.54 \pm 0.23 | 4.20 \pm 0.21 | .. | .. |
| 25-29 years old at observation: | | | | | | |
| Pregnancy rates..... | 482 | 3.12 \pm 0.40 | 4.61 \pm 0.17 | .. | .. | .. |
| Live-birth rates..... | 482 | 2.50 \pm 0.36 | 4.42 \pm 0.16 | .. | .. | .. |
| Weighted average, all ages at observation: | | | | | | |
| Pregnancy rates..... | 956 | 2.87 | 4.82 | 4.49 | 4.27 | 4.17 |
| Live-birth rates..... | 956 | 2.29 | 4.54 | 4.21 | 4.09 | 4.03 |

B. STANDARD DEVIATIONS OF RATES

| GROUP | N | STANDARD DEVIATIONS IN RATES AT INDICATED AGES | | | | |
|--|-----|--|-----------------|-----------------|-----------------|-----------------|
| | | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 |
| 40 years old and over at observation: | | | | | | |
| Pregnancy rates..... | 63 | 5.56 \pm 0.33 | 3.47 \pm 0.21 | 3.47 \pm 0.21 | 4.13 \pm 0.25 | 5.28 \pm 0.32 |
| Live-birth rates..... | 63 | 5.39 \pm 0.32 | 3.48 \pm 0.21 | 2.79 \pm 0.16 | 3.45 \pm 0.21 | 4.30 \pm 0.26 |
| 35-39 years old at observation: | | | | | | |
| Pregnancy rates..... | 169 | 6.33 \pm 0.23 | 4.39 \pm 0.16 | 4.51 \pm 0.17 | 4.19 \pm 0.15 | .. |
| Live-birth rates..... | 169 | 6.24 \pm 0.23 | 3.77 \pm 0.14 | 3.88 \pm 0.14 | 3.94 \pm 0.14 | .. |
| 30-34 years old at observation: | | | | | | |
| Pregnancy rates..... | 242 | 7.38 \pm 0.23 | 4.32 \pm 0.13 | 3.86 \pm 0.12 | .. | .. |
| Live-birth rates..... | 242 | 7.25 \pm 0.22 | 4.18 \pm 0.13 | 3.80 \pm 0.12 | .. | .. |
| 25-29 years old at observation: | | | | | | |
| Pregnancy rates..... | 482 | 10.31 \pm 0.22 | 4.33 \pm 0.09 | .. | .. | .. |
| Live-birth rates..... | 482 | 9.46 \pm 0.21 | 4.13 \pm 0.09 | .. | .. | .. |
| Weighted average, all ages at observation: | | | | | | |
| Pregnancy rates..... | 956 | 8.55 | 4.28 | 4.04 | 4.17 | 5.28 |
| Live-birth rates..... | 956 | 8.06 | 4.04 | 3.69 | 3.81 | 4.30 |

TABLE 9—*Concluded*

C. MEAN AND MEDIAN AGES AT MARRIAGE AND AT OBSERVATION OF THE FOUR COHORTS OF WOMEN DEALT WITH ABOVE

| COHORT | AGE AT MARRIAGE | | AGE AT OBSERVATION | |
|---|------------------|------------------|--------------------|------------------|
| | Mean | Median | Mean | Median |
| First cohort. Observed at 40 and over . . . | 18.21 \pm 0.10 | 18.43 \pm 0.13 | 42.48 \pm 0.14 | 41.98 \pm 0.17 |
| Second cohort. Observed at 35-39 | 17.92 \pm 0.07 | 18.04 \pm 0.08 | 37.67 \pm 0.06 | 37.68 \pm 0.08 |
| Third cohort. Observed at 30-34 | 18.15 \pm 0.05 | 18.37 \pm 0.07 | 32.75 \pm 0.05 | 32.70 \pm 0.07 |
| Fourth cohort. Observed at 25-29 | 18.15 \pm 0.04 | 18.39 \pm 0.05 | 27.74 \pm 0.04 | 27.70 \pm 0.05 |

and 17 years inclusive that only 23 conceived between these same ages, although in approximately 78 per cent of these cases no attempt at contraception had been made. These investigators believe that this low adolescent fertility is probably due to the fact that ovulation normally

Pearl (96) in an investigation, reported in 1939, relating to the fertility of 956 overtly fertile healthy American women who had been continuously exposed to sexual intercourse, found that fertility within the 15-19 year group was very significantly lower than in all the later

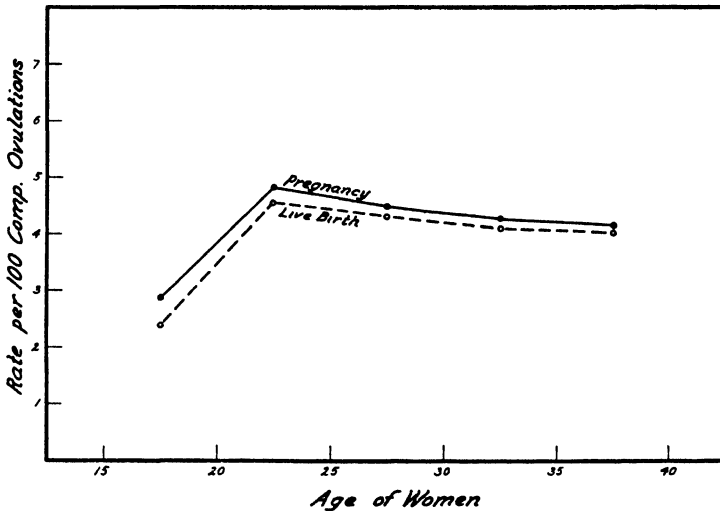


FIG. 1. CHANGES IN THE UNWEIGHTED AVERAGES OF MEDIAN PREGNANCY AND LIVE-BIRTH RATES WITH ADVANCING AGE IN FOUR HOMOGENEOUS COHORTS OF WOMEN IN WHOSE MARRIED LIFE NO CONTRACEPTIVE EFFORTS WERE MADE (PEARL, 1939)

follows only some years after menarche. It would certainly appear reasonable to conclude that of the 69 per cent of post-pubertal females who failed to conceive in this series failure was in the greater number of cases due to the fact that they were physiologically unprepared to do so.

age groups (from 25 to 39 years inclusive) investigated. These facts are well brought out in Table 9 and also in Fig. 1. Pearl comments upon these findings in the following words:

"The low median fertility in the age period 15-19 . . . may be regarded as the

statistical expression of the biological fact, now well established, that in the human species there is a considerable time-lag after puberty before the complete expression of fertility becomes fully established, quite apart from the postponement of marriage" (p. 43).

Some evidence from the earlier anthropological literature may now be cited.

Reporting, in 1861, the observations of Schurmann, Protector of the natives of the Port Lincoln district of South Australia from 1840 to 1846, Wilhelmi (137) states that "Although they married so very young, (10 to 12 years), the women, according to Mr. Schurmann's observations, generally have no children before the age at which they get them in Europe" (p. 164).

Writing of the Fuegians of the southernmost tip of South America, Bove (17) observed in 1883: "The marriages of the Fuegians are, in general, contracted at an early age; at from ten to twelve the girls are already looking for a husband, but they do not become mothers until they are seventeen or eighteen. The men marry at from fourteen to sixteen years of age" (p. 158).

Since the Fuegians customarily marry at menarche, menarchial age must here be assumed to lie somewhere between ten and twelve years of age. At any rate, Bove seems to have been greatly impressed by the considerable duration of the interval which elapses between marriage and motherhood. His evidence is not without value as indicating the possible existence of a period of adolescent sterility among Fuegian girls.

In 1901, referring to the Basuto of South Africa Grützner (44) notes that although intercourse begins at puberty, it is very rare for a girl to become pregnant soon after (p. 114).

Since *effective* contraception is not prac-

tised among any primitive people of whom we have any knowledge (57), an observation such as Grützner's though of doubtful value is at the least worth recording.

Allen Webb (133), Professor of Descriptive and Surgical Anatomy in the Calcutta Medical College, published his observations in 1848 on menarche in Indian girls with the statement:

"I believe that even the fact of the existence of this function [*i.e.* menstruation] having been well established, is no proof of the girl being fit to become a mother,

TABLE 10

Gupta's observations on Hindu women of Calcutta, 1848

| NUMBER OF CASES | AGE AT MENARCHE | AGE AT 1ST PREGNANCY | MENARCHE-PREGNANCY INTERVAL |
|-----------------|---------------------|----------------------|-----------------------------|
| 2 | 11 | 11 | — mos.? |
| 1 | 11 | 14 | 3 yrs. |
| 7 | 12 | — | — |
| 1 | 12 | 12 | 1 mos.? |
| 1 | 12 | 13 | 1 yr. |
| 6 | 12 | 14 | 2 yrs. |
| 2 | 12 | 15 | 3 yrs. |
| 5 | 13 | — | — |
| 1 | 13 | 13 | — mos.? |
| 7 | 13 | 14 | 1 yr. |
| 2 | 13 | 15 | 2 yrs. |
| 1 | 13 | 16 | 3 yrs. |
| 1 | 13 | 18 | 5 yrs. |
| 37 | Average = 12.3 yrs. | Average = 14.1 yrs. | Average = 1 yr. 10 mo. |

that is, to bear a living child. Almost the only instances I have known here, of instrumental labour in European-bred females, were from their having married too young" (p. 261).

Through the agency of an Indian physician and scholar Babu Modusuden Gupta (45) Webb was able to obtain the ages of menarche in 37 Hindu women, 25 of whom had been pregnant and for whom the age at first pregnancy was available. Gupta's data is presented in Table 10.

Gupta's data for the 25 individuals who

had experienced pregnancy shows that 4 individuals, or 16 per cent, had conceived within the first year, 8 individuals, or 32 per cent, within the second year, 8 individuals, or 32 per cent, within the third year, 4 individuals, or 16 per cent, within the fourth year, and 1 individual, or 4 per cent, within the sixth year. First pregnancy did not occur until more than a year to three years after menarche in 80 per cent of the cases.

The first investigator to collect data systematically on the reproductive life of a non-European people appears to have been A.-T. Mondière, a physician with anthropological interests who, during the

Table 11 one year should be deducted from the ages at menarche and birth of first child to allow for the Chinese method of reckoning; this would, however, make no alteration in the duration of the sterility interval in the fifth column of figures. Mondière was much interested in the differences presented by the four groups in the duration of the menarche-parturition interval, and suggested that since the climatic conditions were identical for all these groups the difference in the intervals must be attributed to racial factors. He felt, however, that the rather considerable sterility interval in the Cambodian women was possibly in some

TABLE 11
Mondière's observations on the women of Cochín-China, 1880

| PEOPLE | NUMBER OF CASES | MEAN AGE AT MENARCHE | | NUMBER WITH FIRST CHILD | AGE AT BIRTH OF 1ST CHILD | | STERILITY INTERVAL* | |
|----------------|-----------------|----------------------|--------|-------------------------|---------------------------|--------|---------------------|--------|
| | | years | months | | years | months | years | months |
| Annamite..... | 980 | 16 | 4 | 440 | 20 | 6 | 3 | 4 |
| Chinese..... | 106 | 16 | 6 | 15 | 18 | 10 | 1 | 6 |
| Min-Huong..... | 62 | 16 | 9 | 40 | 20 | 9 | 3 | 2 |
| Cambodian..... | 96 | 16 | 10 | 45 | 22 | 6 | 4 | 10 |

* The calculation of the sterility interval from menarche to conception (= - 10 months from parturition) has been added by the present writer.

latter part of the last century spent some six years working among the inhabitants of Cochín-China. He reported his observations in 1880 (85), and later, in 1886 (86), reproduced them in summary form in an article. Hartman (52) quoted from this article in his 1931 communication to *Science* on the relative sterility of the adolescent organism, and in that communication the figures reproduced differ very slightly from those given by Mondière. Here Mondière's figures (Table 11) are reproduced from his monograph which gives the essential figures in somewhat more detail than in the article from which Hartman quoted.

It is possible that from the figures in

way connected with the fact that among this people the husband, as a rule, was more than twenty years older than his wife. In each of the five groups the girl was generally married at the establishment of menarche.

The results of this investigation led Mondière to the conclusion that the arrival of "nubility is more an affair of race than a matter of climate" (86, p. 824).

Among all these peoples contraceptive practises were entirely unknown and children greatly desired. Whatever Mondière's findings may actually mean, it is unnecessary to do more here than to suggest that they indicate the possible existence of a period of adolescent sterility

among the peoples of Cochin-China investigated by him.

In his articles "Nubilité" and "Puberté" in the *Dictionnaire des Sciences Anthropologiques* published between 1886-1894 Mondière clearly recognizes the difference between puberty and the period at which actual reproductive capacity appears. In the article on "Nubilité" he writes:

"Nubility is frequently confused with puberty, but it is a very different thing. With the establish-

mission to use them in the present paper (Table 12).

The average age at menarche of these women was 16.13 years, with a range of 13 to 21 years. First effective intercourse took place at an average age of 17.38 years with a range of 13 to 23 years, and first childbirth at 20.02 years, with a range of 15 to 26 years. Table 12 represents the distribution in this group of women of the intervals between menarche and first childbirth irrespective of age; the figures

TABLE 12

Interval between menarche and first childbirth in 99 Chinese married women from South Fukien

| INTERVAL..... | LESS THAN 1 YR. | 1 YR. | 2 YRS. | 3 YRS. | 4 YRS. | 5 YRS. | 6 YRS. | 7 YRS. | 8 YRS. | 9 YRS. | NO. PREG- NANCY |
|-------------------|--------------------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------------------|
| No. of cases..... | 3 | 6 | 17 | 11 | 15 | 7 | 8 | 5 | 3 | 4 | 20 |
| Per cent..... | 3.0 | 6.0 | 17.0 | 11.0 | 15.0 | 7.0 | 8.0 | 5.0 | 3.0 | 4.0 | 20.0 |

ment of nubility there follows not only the possibility, but the capacity for normal reproduction. Puberty manifests itself late or early, nubility exists only when the woman is without danger able to give birth to a new being. The sperm in the adolescent although secreted at the period of puberty does not perhaps possess the qualities necessary for producing a regular segmentation of the ovum; and in the young woman, if conception takes place, it is doubtful whether the foetus will be brought to term, and the pregnancy is excessively dangerous both for the mother and offspring. The age of nubility falls into the period of adolescence, that is to say from eleven to twelve years in the female until twenty or twenty-one years, and strictly speaking the term should be applied only to this period" (86, p. 823).

Similar views are expressed by Mondière in the article on "Puberté," (87, p. 941), in the same work.

More than thirty years ago Professor J. Preston Maxwell of Peiping Union Medical College carried out an investigation on 99 married women of Yung Chun in South Fukien, China, relating to menarche, marriage, first delivery, and footbinding. These data were never published by Professor Maxwell, and I am greatly indebted to him for his gift of them and his per-

TABLE 13

*Interval between menarche and first childbirth in 34 Chinese women married before the establishment of menarche**

| | | | |
|---|--------|--------|------------------|
| Age at menarche | 15-16 | 17-18 | 19-20 |
| Number | 14 | 13 | 7 |
| Age at marriage | 14-15 | 16 | 16 |
| Age at first child | 18-19 | 19-20 | 21-23 |
| Number | 11 | 13 | 6 |
| Menarche-childbirth interval | 3 yrs. | 2 yrs. | 2 yrs. 6 mos. |

* All ages are according to Western reckoning.

make it clear that in only a very small percentage of cases is menarche followed by pregnancy within the first year. Of these women 34 had arrived at menarche from 1 to 5 years before marriage, as shown in Table 13.

The small number of cases available hardly renders Table 13 an impressive one, and since also Professor Maxwell's data were gathered in terms of years without record of months, this table is probably far from actually representing the facts; but such as it is, it does exhibit something

of a general trend, the younger 15-16 year age group apparently taking a longer time to overcome their initial infecundity, and being more often sterile (3 cases) than is the case in the older groups. This is again borne out by the figures for the whole group arranged by age at menarche, as is seen in Table 14.

This table gives a striking illustration of the gradual decrease in the sterility interval as the adolescent female arrives later at menarche. Similar findings have recently been obtained by Mills and Ogle (79) on data relating to white and negro mothers of illegitimate children. These investigators note that "The sterile lag period from menarche to first conception

Clearly such figures are of very little worth for our purposes, although in a very general way they may be regarded as not without some suggestive value. Were we to take these data at their face value we should have to suppose an average sterility interval of some 6 years. One cannot be certain that such an average interval is at all unlikely. It may be recalled here that among the natives of Wogeo, in New Guinea Territory, menarche generally arrived at seventeen and despite frequent intercourse during the interim it was not usual for a girl to give birth to offspring until she was twenty-two; this yields a sterility interval of five years. However, until further investigations have been

TABLE 14
Menarche-conception interval in 99 South Chinese married women

| | | | | | | | | | |
|-----------------------------------|------|------|-----|------|------|------|----|------------|------|
| Number of cases..... | 6 | 11 | 29 | 16 | 18 | 9 | 3 | 5 | 2 |
| Age at menarche..... | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| Age at marriage..... | 18 | 17 | 16 | 16 | 16 | 18 | 17 | 17 | 22 |
| Age at 1st child..... | 21 | 20 | 19 | 20 | 20 | 21 | 21 | 22 | 27 |
| Number of conceptions..... | 3 | 2 | 2 | 4 | 3 | 1 | 0 | 2 | 1 |
| Per cent of conceptions..... | 50.0 | 18.2 | 7.0 | 25.0 | 16.6 | 11.1 | — | 40.0 | 50.0 |
| Menarche-conception interval..... | 7 | 5 | 3 | 3 | 2 | 2 | 1 | (1 5?)* | |
| | | | | | | | | 1 yr. | |

* The combination of the 20-21 year groups yields a more accurate figure of 1 year for the interval here.

... exhibits a steady shortening as we go from earlier to later menarchial age" (p. 64). Such facts would suggest that the more mature the soma the shorter will be the sterility interval following menarche.

Chau and Wright (19) in a report in 1925 of an investigation carried out on 2,291 South Chinese women living in sub-tropical Canton (N. Lat., 23° 7' 10") and surrounding districts, found the mean age at menarche to be 14.5 years; the mean age at marriage (683 cases) 17.6 years, and the mean age at birth (596 cases) of the first child 20.5 years. Only one girl became a mother at the age of 13 years; five at the age of 15, and twelve at the age of 16.

carried out in this and in other regions of the world it will not be possible to say with any degree of security whether such an *average* interval occurs in any human group.

Mills and Ogle (79) in a paper already referred to have presented the following data, collected from hospital records by Mills (Table 15).

From Table 15 it is to be noted that the fertility interval appears to be about three years longer in the married than in the unmarried except in the case of the Manila groups where the interval is practically the same for the married and the unmarried. The authors think the latter coincidence in age at first childbirth (6.33 years

after menarche) reflects "a real expression of physiologic sterility," since "sex relationships in Manila are perhaps as free from social or moral restraint as anywhere on earth" (79, p. 611). This may be so, but we are not told when effective intercourse begins in any of these groups, hence it does not seem to me that the figures in the last column can have any real significance for our purposes. This is, however, not the case when we examine the material for the interval between marriage and

is followed by an average lag before the first conception (as determined by the deduction of 10 months from age at first delivery) of 2.00 years. It seems likely that the greater "fertility lag" in the married as compared with the unmarried is due to the fact that the married generally begin effective intercourse appreciably later than the unmarried. The figures for Manila relating to childbirth in the unmarried and the married may, as Mills and Ogle believe, reflect the actual

TABLE 15
*Menarche, marriage and first birth data**

| CITY | SUBJECTS | DATE | NO. | MOTHERS AGE IN YEARS AT | | | LAG IN FERTILITY (MENARCHE TO FIRST CONCEPTION) |
|---------------|----------------------------|------|-----|-------------------------|------------------|------------------|---|
| | | | | Menarche | Marriage | 1st delivery | |
| Cincinnati | Unmarried Negroes | 1924 | 33 | 13.44 \pm 0.13 | | 18.08 \pm 0.28 | 3.89 |
| | White and colored, married | | 131 | 13.68 \pm 0.08 | 19.09 \pm 0.17 | 20.48 \pm 0.19 | 6.05 |
| Richmond, Va. | Unmarried Negroes | 1934 | 56 | 13.46 \pm 0.09 | | 18.21 \pm 0.19 | 4.00 |
| | Married Negroes | | 52 | 13.75 \pm 0.17 | 19.63 \pm 0.17 | 21.60 \pm 0.43 | 7.10 |
| Panama | Unmarried Negroes | 1934 | 72 | 14.04 \pm 0.09 | | 19.26 \pm 0.20 | 4.47 |
| | Married Negroes | | 56 | 14.05 \pm 0.14 | 21.01 \pm 0.27 | 21.93 \pm 0.32 | 7.13 |
| Manila | Unmarried Filipinos | 1934 | 22 | 14.73 \pm 0.16 | | 21.82 \pm 0.50 | 6.33 |
| | Married Filipinos | | 84 | 14.58 \pm 0.12 | 20.49 \pm 0.30 | 21.88 \pm 0.30 | 6.55 |
| Hongkong | Married Chinese | 1934 | 284 | 15.82 \pm 0.06 | 18.27 \pm 0.11 | 21.00 \pm 0.12 | 4.97 |

* After Mills and Ogle, Tab. I, (1936).

conception; for Cincinnati whites and Negroes the interval is 0.59 years; 0.37 years for Richmond married Negroes; immediate conception in Panama married Negroes; 0.59 years in married Filipinos at Manila, and 2.00 years in married Chinese at Hong-Kong. Hence, the only evidence of any significance yielded by this data is that although Chinese Hong-Kong married women arrive at menarche at an average age of 15.82 years and marry at an average age of 18.27 years, marriage

existence of a physiologic sterility interval here of 6.33 years; we should, however, want to see much supporting evidence from Manila before we could accept such a figure as a fact. We have already seen that in two separate Chinese groups such a period of sterility has already been recorded by two independent investigators, but the same criticisms apply to their findings as to those of Mills and Ogle. Incidentally, it is desirable to point out here that Mills and Ogle's last column in

Table 15 is unjustifiably labelled "lag in fertility." This column obviously reflects nothing of the sort; what it gives is what is stated in the introduced parenthesis, namely, the interval between menarche and conception—a very different thing.

The 2.00 years interval following marriage (2.65 years after menarche) before the first conception among Hong-Kong Chinese may reflect the existence of a period of sterility; but what this may be due to is another matter. In spite of the statement of Mills and Ogle to the contrary I have been informed by Professor J. Preston Maxwell, Professor of Gynecology and Obstetrics at Peiping Union Medical College, that the desire for children is to-day by no means as great as it formerly was in such places as Hong-Kong, and that contraceptive practices are far from unknown among the native population. However, the low economic level of the Chinese here reported may be an additive factor in complicating the evidence. These objections, of course, apply to all the evidence which has thus far been cited. The evidence of Mills and Ogle, though clearly by no means conclusive, does at any rate, point in the direction of a probable adolescent sterility interval among the peoples cited.

A certain amount of material exists for Indian women which may be discussed here. In *Mother India*, published in 1927, Mrs. Katherine Mayo (75) drew attention to what she esteemed to be the fact that "The Indian girl, in common practice, looks for motherhood nine months after reaching puberty, or anywhere between the ages of fourteen and eight. The latter age is extreme, though in some sections not exceptional; the former is well above the average" (p. 22).

At the time of their publication these statements among others excited much indignation which found expression in the

Indian press and elsewhere. But long before the advent of Mrs. Mayo's book the child-mothers of the East had become an established feature of orthodox Western tradition relating to the East. Child-mothers there are in India, but they are not usually to be found "between the ages of fourteen and eight." As long ago as 1848 Webb (133) had already shown that:

"It is not common for girls in India to begin to menstruate until after the 12th year. . . . Out of a list of 127 Hindoo females with which I have been favored, it began only in 6 girls under 12 years of age, and as many of them did not again menstruate until a year after this which they believed a *first appearance*, it is probable . . . that a ruptured hymen would account for that. Thus 81 out of 127 are stated to have been 12 years old or upwards.

"Out of eighty cases thus furnished who had probably been subjected to the influences of impregnation from the age of nine years, there were only 28 births under 14 years of age, but similar results would perhaps have followed in Europe. . . . Out of 127 cases reported to me of Bengalees, one birth is stated at 8, and one at 9" (p. 254).

According to more modern evidence, for example, the Indian Census Report for 1931 "the average age of females at marriage is 13.33 years and of males 17.98 years," the females seldom going to live with the husband until after puberty (in the Punjab, at least), (65). According to the Indian Census Report for 1921, the first child in the great majority of cases is born in the *third year* of effective marriage, i.e. dating from menarche (77). This puts the mean age of the mother at 16 years and some months. According to a statement, made in 1928 by Clark (21), of the figures from the Maternity

Hospital at Seva Sada in Amednagar in which Presidency early marriage is said to be more prevalent than in any other part of India, the average age of the mother at first delivery is 18.3 years. In 1927 Dr. M. I. Balfour (13) of Bombay, in an account of 6580 primiparous mothers from many parts of India, stated that none were under 13 years of age, 7 recorded as 13, and 35 as under 15. The average age of the mother at the birth of her first child was 18.7 years in Bombay, and 19.4 years in Madras. In both Bombay and Madras respectively 85.6 and 86.2 per cent of the mothers were more than 17 years of age. These figures show that less than 1 per cent of Hindu women were mothers before they were 15 years of age and none before the age of 13.

An analysis of Curjel's (25) report of 1920 on menstruation in 545 Calcutta women of various social classes yields a mean age of 14.21 years for age at menarche, a figure which would give an average adolescent sterility interval for the Indian woman of approximately 4 years. It may be noted here that in 1930 Pillay (98) stated in connection with Calcutta women that "An analysis of about 700 cases shows that the age of puberty is 13 or 14, and the age of the birth of the first child is 14 or 15."

These statements would, upon the face of them, seem to be extremely doubtful; at any rate, they are lacking in confirmation, and, unfortunately, Pillay does not present the detailed figures upon which they are based.

The imaginative order of Mrs. Mayo's statements is, I think, fairly clear; not that the evidence which has been cited in this connexion is altogether satisfactory; it is not, and we have yet far to go before accurate and reliable data will become available for conditions in India; but such as it is, this evidence does render

Mrs. Mayo's statements extremely doubtful. The fact is that the youngest mother seen by Mrs. Mayo was, as she herself records, 12 years of age; and *she* was probably older! It is a fact, perhaps not too well known, that white observers almost invariably underestimate, by years the ages of native children, who, owing to undernourishment and a variety of other factors appear so much less developed than white children at similar ages. Reche (103) has suggested that this is in part due to the lateness with which the secondary sex characters appear in such children. It is of some interest to note that in the adults of such peoples the tendency is greatly to overestimate the age of individuals (1). Professor C. A. Mills informs me that during his widely extended investigations among native peoples in various parts of the world it was invariably his experience that when he was able to check his own estimate of the age of an adolescent or a child by some official birth record, he always found his own estimate to be too low. Actually it is extremely doubtful whether there exists any people among whom the mean age at menarche is less than 13 years.

Nicora (90) in a paper published in 1938 reports that out of 390 pregnant Italian girls ranging in age from 11 to 17 years only one girl became pregnant before the commencement of menstruation, while two others had only menstruated for 2 and 6 months respectively prior to conception; the remainder did not become pregnant until a more appreciable period of time had elapsed following menarche. It is not stated, however, when active intercourse commenced in each case.

Dr. Henry Geist who was superintendent of the Presbyterian Hospital at Point Barrow, Alaska, from 1920 to 1936, informs me that among the Eskimo of that vicinity although puberty and intercourse

commenced at a relatively early age (between 10 and 12 years?) pregnancy before fifteen years of age was extremely rare. Contraceptive practises were entirely unknown (42, 135).

It is, of course, perfectly well known that some girls in India, as elsewhere in the world, are capable of bearing children at a chronological age of less than 13 years, and that they may menstruate long before they have reached that age; in many cases the chronologic age at menarche may be unusually low (2, 26, 47, 59, 68, 90), but there can be little doubt that in normal cases the *physiologic* age, that is to say, the actual developmental status of such girls as measured against chronologic time, is commensurate with that of the chronologically older girls. Arbitrary chronologic standards of age, it must be clear, are only of secondary importance in the consideration of these matters. The well-authenticated cases of girls who, at 8 or 9 years of age, have borne children are relatively few, and though these cases are exceptional in terms of chronologic age for a normal population, there is more than a doubt that they are in any way exceptional in terms of physiologic age. At any rate, such cases being as rare as they are, do not have to be considered in discussing the normal conditions. A girl of less than 13 years of age may be as sexually mature as a woman of 25, and a woman of 25 may be as sexually immature as a normal girl of less than 13 years of age. Such cases are obviously abnormal, but the state of development in such cases does serve to explain why girls of the former class are able to conceive at so early a chronologic age.

DISCUSSION

The evidence cited in the foregoing pages quite clearly shows that the im-

mature female who is less than 20 years of age conceives much less easily and much less frequently than the mature female up to 30 years of age; that a high percentage of these younger women are relatively sterile, and that prior to the age of 20 years the process of childbearing constitutes a hazard to the life of both mother and child which increases in proportion to the youthfulness of the mother and decreases to a minimum at maturity (30, 48, 67, 69, 87, 88, 90, 133). All the evidence has pointed strongly in the same direction, namely, to the conclusion that the immature female is biologically immature, developmentally unprepared, for the processes of reproduction; that when these processes are early initiated and exercised before maturity is reached the well-being of the mother and of the child is endangered. In young adolescent females there generally exists a pattern of conditions which in the largest number of cases tends to secure such females against undergoing an experience for which they are biologically not adequately prepared. This is putting the matter somewhat teleologically; it would, perhaps, be more correct to say that the adolescent organism being itself in process of development is not generally endowed with the capacity to perform the functions of reproduction until it has reached a certain stage of efficient differentiation. This latter stage depends upon the capacity, among other things, to produce mature ova; and this is a capacity which, as we have seen, there is good reason to believe is not attained in most mammals until some appreciable time after the appearance of the first oestrous or menarche.

The ontogenetic developmental history of all mammals consists in a process of differentiation in which organ-systems undergo a differential development, at rates and in regions which follow one

another in a definite serial pattern, at more or less definite moments of time as determined by the system in which the developmental process proceeds. The process begins with the fertilization of the ovum and terminates with the attainment of maturity. In the human female the evidence points to the age of 23 ± 2 years as the age of maturity. The optimal conditions for reproduction prevailing in the organism at that time, i.e. at the age of 23 ± 2 years, are maintained for about 5 years, at the end of which time the process of involution commences and at about 45 years expresses itself in the menopause, terminating finally with death. Puberty represents an early transition period in the total developmental process, during which maturation gradually takes place in certain parts of the reproductive system, and leads to the phase of development which we recognize as maturity, the period when the organism actually becomes capable of efficient reproduction. Puberty is the bridge which leads from childhood to maturity.

In what immediately follows we shall briefly discuss the developmental physiology of the primates with particular reference to the human species in so far as it relates to the functions of reproduction. We must determine to what extent, if any, the physiological evidence supports the idea of the existence of a period of adolescent sterility in the primates.

Development consists of growth, or increase in size, and differentiation, or increase in complexity. At fertilization the process of development is initiated in the ovum by the spermatozoon; there is immediate growth and gradual increase in complexity. Throughout the process of development growth seems to be one step ahead of differentiation. The spermatozoon contributes the determiners of sex in the form of a definite chromosomal

structure which eventually leads to the development of one or another particular set of sex characters, according as the chromosomal structure is of the male or of the female pattern. The development of these characters in the mammals is presumably brought about by certain chemical agents which there is good reason to believe are already present at the so-called "sexually indifferent" stage of development of the organism: the stage during which the sex of the organism cannot ordinarily be determined save by reference to its chromosomal pattern. These chemical agents are probably related to or are identical with the *organizers* which have been postulated by Spemann as responsible for the early differentiation of tissues and the induction of organ formation; and it is not unlikely that these "organizers" are the primordial representatives of the growth and sex hormones of the older organism (134, 134a, 138). At any rate, it appears that from a very early stage in development the general somatic differentiation and sexual differentiation of the tissues of the organism proceed together, inseparably. All development, in short, is sexual development, the distinction between morphologic and sexual development being an arbitrary one. The process of development consists in the organization of tissues for the fulfillment of certain definite functions; structures have no other meaning than this, and apart from living the chief function of every organism is reproduction, and to this end all development would seem to proceed. Tissues and organs undergo development at rates and in regions which are related to one another in circumscribed serial patterns, so that one process or event cannot occur without exercising a definite influence upon others within the system; and the general pattern of development is such, throughout the animal kingdom, that the

functional qualities of a tissue or an organ are always preceded by growth and increase in complexity in such tissues and organs. The gradual development of the functions of the body system are dependent upon the rates of growth and differentiation of the tissues comprising it; and in the ontogenetic development of any animal a particular succession of changes must occur before any one of these functions can be established. So it is with the development of the structures and functions devoted to the reproductive system. These do not appear in the newborn infant in a state ready for the performance of the processes of reproduction, but a long period of years must elapse during which the necessary changes must occur which eventually render reproductive activities possible.

The great characteristic of development as a spatio-temporal phenomenon is its gradualness.

It is to-day a fairly well established fact that at birth the individual is in possession of most of the elements necessary for reproduction. Thus, ova are present in the ovaries, and the pituitary contains gonadotropic hormones (119, 139), these when injected into older animals are capable of inducing ovulation in the latter. Anterior pituitary hormones, as a rule, are incapable of producing ovulation in the newborn animal. As the animal grows, however, ovarian reactivity to the hormone becomes established, and as sexual maturity is approached the amount of hormone necessary to produce a given reaction progressively decreases. While the ovary is capable of reacting to gonadotropic hormones already present in the anterior lobe of the pituitary at a very short time after birth, yet under normal physiological conditions it does not do so until long afterwards. It has been suggested that this is due to the fact that

though the pituitary contains gonadotropic hormones at this early stage, they are not poured into the blood before a definite stage of development has been reached (110).

Whether the increasing reactivity of the ovary is due to an increase in the effectiveness or quantity, with age, of the substances acting upon the ovary, or to an autochthonously developing sensitivity of the ovaries themselves, the available evidence renders it certain that the processes leading to the development of ovulation are of a very gradual nature (19, 24, 32, 33, 34, 52, 53, 110, 121, 150).

In order that a female animal may conceive and bring the process of pregnancy to a successful termination, it is necessary that her ovaries should be able to produce mature ova capable of being fertilized, then implanted in the uterus, and there acted upon in such a manner as to cause the fertilized ovum to undergo development up to the stage when the developed organism is ready for birth. All these processes require the presence in the maternal organism of a number of conditions. Without the presence of any one of these conditions reproduction cannot occur. These conditions come into existence in a definite order in physiologic and chronologic time, before the establishment of which as a functional complex the female cannot reproduce. If she is not yet able to ovulate she obviously cannot be impregnated, and if she is able to ovulate the absence of a luteinizing hormone may make it impossible for the fertilized ovum to become attached to the uterine wall. Now, it is just these two conditions, ovulation and formation of the corpus luteum, which do not normally become functionally established until some time after puberty, if in the conventional sense we here take puberty to mean the

period of the first oestrous or menstruation.

Van Herwerden (129), Allen (3), Hartman (51), Corner (23), and others, have shown that the early menstruations of the female rhesus monkey are normally unaccompanied by ovulation. It is thus impossible for the early menstrual rhesus female to conceive. There is good reason to believe that the same holds true for the human female (52). What happens at puberty is this: As the general process of growth, over which the growth hormone of the anterior pituitary has presided, slows up, this gland pours into the blood stream a hormone, the follicle-stimulating hormone, which has the effect, *ceteris paribus*, of activating the ovary to elaborate a hormone, oestrin, which is not only responsible for the gradual appearance of the secondary sex characters, but also for the induction of all those changes in the reproductive tract which result in menstruation. Ovulation, however, does not and cannot occur as the result of the action or in the presence of, oestrin alone; at puberty oestrin is alone present in appreciable amount. For ovulation to take place another fraction, or hormone, of the anterior pituitary must come into play, and this is the luteinizing hormone. Unfortunately, it is not known at what age an amount of luteinizing hormone sufficient to produce ovulation makes its appearance in the blood. Actually it is not altogether certain whether the follicle stimulating and luteinizing hormones exist as separable fractions or merely represent different states of a single gonadotropic hormone (111), or whether the ovary itself undergoes a series of differential changes for quite other reasons which eventually enable the gonadotropic hormone to call forth the proper response. But whatever the facts may be it is known that oestrin, which is alone sufficient to

produce those overt phenomena which we collectively term puberty, briefly, the appearing secondary sexual characters and early menstruation, is not sufficient to produce ovulation. Hence, it is clear that the first or early menstruations must be unassociated with ovulation; and, therefore, it is impossible for a female, under normal conditions, assuming the non-ovulatory character of the early menstruations to be the normal condition, to conceive in the early phase of puberty.

How long this early or primary phase of puberty lasts in the human female it is at present impossible to say. The period is, no doubt, a very variable one, and is probably linked with genetic factors the expression of which is doubtless subject to modification by environmental factors.

It is only when the second hormone of the pituitary, the luteinizing hormone, is poured into the blood stream in sufficient quantity, or the ovary reaches the proper stage of differentiation or sensitivity, following the establishment of menarche, that ovulation and impregnation become possible. This is the period of *nubility*, and as more than one earlier author has pointed out, is not to be confused with the earlier period of puberty. We have already seen that in the lower mammals and in the subhuman primates, nubility generally follows puberty only after a fairly appreciable amount of time has elapsed. Such evidence as we have for man indicates in no uncertain manner, that a similar appreciable interval of time must separate the two events or periods in the human species.

Gynecologists such as Waddy, Joulin, and Matthews Duncan, had already clearly recognized this fact three-quarters of a century ago, but the scientific world allowed their suggestive evidence to pass unnoticed, and it has remained for modern experimental research in the physiology

of sexual development and reproduction of the lower mammals to rediscover and to provide the scientific demonstration of the truths of these early investigators. Something of the nature of this demonstration it has been attempted to give in the above passages. We may now, however, examine, and perhaps anticipate some of the possible objections to the interpretation of the meaning of adolescent sterility here given.

It is a well known fact that many apparently healthy girls have given birth to children at such early ages as 8 and 9 years, and that many such girls exhibit the characters of mature women, (2, 39, 47, 48, 66, 68, 84, 90, 104). In individuals of the latter variety some disorder of the ovaries or adrenals is usually, though not always, demonstrably responsible. In many cases where no pathologic process can be demonstrated it is nonetheless possible that such a process is at work, but in so many others it seems quite unnecessary to look for a pathologic factor, for what has impressed students of many of these cases of early motherhood and precocious sexual development, has been the fact that, as Harris (48) put it in 1873, in these girls their "physical development [is] in correspondence with their sexual" development, "and the whole system is in correspondence with it, so that the function [i.e. menstruation] does not, in its performance, interfere with the growth or health of the subject," (47).

In such cases of premature sexual development we are dealing with a general speeding-up of the normal processes of development, so that a girl of a chronologic age of 10 years may actually be of a physiologic or developmental age in all or most of her characters characteristic of a woman of 25 years or more. Such cases are merely a further illustration of the fact that reproductive capacity is

dependent upon physiologic development. Chronologic age is altogether unimportant here; physiologic age is the important thing. Early chronologic reproductive capacity is a striking thing only because it happens to present a deviation from the modal chronologic age at which women usually become capable of bearing children. Such deviant individuals are deviant only because of the rate at which they have developed, but in all other respects they are physiologically normal.

With respect to those cases in which the sexual precocity is traceable to some abnormal initiation of endocrine activity, which like magic ceases upon the removal of the exciting agent, usually a tumour (18, 39, 66, 68, 104, 144), such cases, when they occur in pre-pubertal or adolescent individuals, merely constitute a further illustration of the fact that development towards maturity is dependent upon the functioning of certain organs, and that in the normal individual the functions of these organs are only gradually established, but that in such individuals these functions may come into action prematurely as a result of the abnormal excitation of the organs regulating them.

Such cases do not, of course, present anything irreconcilable with the evidence for the existence of an adolescent sterility interval in man, or in any other animal species. Finally, it may be added, that while we nearly always hear of the child who has given birth to an infant, we very rarely hear of the numerous children who at one time or another have been exposed to sexual attentions from men, without ever conceiving. Yet there can be no question that such cases occur in our own and in other societies.

An important fact which was first brought out in 1931 by Hartman (52) in connexion with his studies on macaques, was that maturity, or the period at which

his animals were first able to conceive, was correlated with their general body growth with particular reference to weight. In his animals menarche occurred at an average body weight of 3000 grams, but ovulation and fecundity were not attained until the average weight of 5000 grams was reached, thus representing a sterility interval of about one year. That maturity in the present particular sense as well as in the more general sense in which the term is used is a function of growth is obvious. In the recent study by Schultz and Snyder (114) on the reproduction of the chimpanzee it has been suggested that the sterility interval is related to the entire growth period in an inverse manner, according to the formula: the shorter the growth period the longer the sterility interval. Thus, these authors wrote in 1935:

... "observations available so far, seem to indicate that the period of so-called adolescent sterility is longest in the most primitive form, the macaque, appreciably shorter in the higher primate, the chimpanzee, and shortest, if indeed existing at all, in man. These differences are all the more significant in view of the fact that the entire growth period is shortest in the macaque (about 7 years), much longer in the chimpanzee (11 years) and longest in man (20 years)" (p. 198).

But does it not appear more likely that if the entire growth period is longest in the higher primates that the periods of infancy, childhood, adolescence, and maturity would be somewhat more extended in duration in them as compared with the lower primates in which the growth period is somewhat shorter? Indeed, this has long been known to be the case, and has recently been abundantly demonstrated by Spence and Yerkes (123) for the chimpanzee as compared with man. It might be further argued that if the adolescent period is of greater duration in the higher primates, that is to say, the period

elapsing from menarche to primary fecundity or nubility, then *ipso facto* the sterility interval should be longer in the higher primates than in the lower primates. Certainly the interval appears to be considerably greater in man (3 years?) as compared with macaque (1 year?). As for the chimpanzee only 4 reliable records are at present available and these give sterility intervals of respectively 4, 10, 12, and 13 months. What the actual degree of variability and the mean duration of this period is in the chimpanzee it is at present hardly possible to say, but until further reliable evidence becomes available it seems reasonable to assume that in these respects the chimpanzee resembles man more closely than it does the macaque—in the present indicated sense, and not in that suggested by Schultz and Snyder. Where the latter appear to have erred is in their original uncritical acceptance of Hartman's (54) statement that "no adolescent female has conceived during the first two years after puberty" (p. 23). We have already seen that the correct figure is actually about 1 year, as originally given by Hartman (52) in his 1931 communication.

Furthermore, the fact that many apparently normally developed girls are capable of conceiving immediately after the appearance of menarche does not constitute a disproof of the fact that a still larger number of girls are incapable of conceiving at this time; and *that* is the important point. If the overt evidence did not indicate as much, our knowledge of the physiology of sexual development in the human female would demand it.

CONCLUSIONS

The evidence presented in this paper strongly supports the view that in the females of the mammals thus far investigated, namely, mouse, rat, macaque,

menstruation, and man, the ability to reproduce is not, in the large majority of cases, synchronous with the appearance of the first oestrous, or the first overt expression of puberty, the menarche. The physiological prerequisite of reproduction is ovulation and its associated processes; since these do not normally develop until some time after the advent of puberty, conception and reproduction are therefore impossible at the inception of puberty. Before ovulation can take place the endocrine system and the soma must reach a certain level of development; when this level of development is attained ovulation then takes place, and the organism is then said to be *nubile*, the state of development at which it becomes capable of conceiving and reproducing. Nubility and puberty are stages of development which are often confused with one another, but in reality they represent two very different developmental stages. The interval from the inception of puberty to nubility is termed the *adolescent sterility interval*, the period of adolescence during which the animal continues to be functionally reproductively sterile. Obviously, this interval is not, because of its sterile character, distinguishable from any of the preceding periods of development; it is here merely termed the adolescent sterility interval in view of the necessity of emphasizing what appears to be the fact that puberty and the power to procreate are not synchronous events, but that the arrival of the one is separated from the development of the other by an appreciable interval of time, and that this interval represents a period of time during which the organism continues to be sterile. This is not generally recognized to be the case. Puberty is most commonly believed to be the sign of the development of the capacity to reproduce, and the only interval at all recognized is that between puberty and

maturity, the period of adolescence. Maturity is generally taken to be the period which commences at the time when the growth of the organism comes to an end, in man at about 23 ± 2 years. This view, the evidence indicates, does not appear to be sound. The period of adolescence does begin at puberty, but the power to procreate follows only at some time after this developmental stage has been attained,—at the period of ovarian maturation when ovulation becomes possible, and when conception may follow, the period of nubility. This period, that is nubility, is not coincident with maturity but represents the bridge, as it were, between puberty and maturity; maturity being attained only at an appreciable time after the development of nubility. The period of nubility is not by any means the best time for procreation; it is, on the other hand, the worst, being characterized by high maternal and infant mortality (67, 69). The best time for reproduction is unquestionably at the age of early maturity, when the female organism is fully prepared to undertake and carry through the processes of reproduction satisfactorily.

The physiological basis for the period of adolescent sterility is clear: it is simply that the endocrine glands which must pour their hormones into the blood stream before ovulation and reproduction can take place, do not normally do so during the menarchial or immediately post-menarchial period, but only at a later stage of development, which we then term the period of nubility.

The period of nubility is, among other things, only the mark of a step in the maturation of the sexual equipment for the process of reproductive functioning; it does not by a long way represent the completion of that maturation, but only the beginning. Hence, we would define

puberty as the period of the inception of those changes in the reproductive system which are exhibited in the appearance of the first oestrous or menarche, and in the gradual development of the secondary sexual characters.

Physiologically this means that the pituitary now elaborates the follicle-stimulating hormone which acts upon the ovary in such a manner as to cause the latter to produce its own hormone, oestrin, which in turn acts upon the genital tract in a specific manner and results in the appearance of the first oestrous or menarche, and the development of the secondary sexual characters. At this stage of pubertal development the organism is normally sterile.

The changes in this way initiated at puberty are followed, after the lapse of some time, by a unique development, namely, ovulation; this marks the period of nubility, which may be defined as that period of development in which the function of ovulation is established in the growing organism.

Physiologically this period is characterized by the secretion of a second hormone of the pituitary, the luteinizing hormone, which acts upon the ovaries in such a way as to cause an ovum in one of them to burst through the ovary and to pass into the uterine tube, leaving behind its follicular investment, which in the wall of the ovary undergoes reorganization into a luteal body the secretion of which, progesterone, prepares the uterus for pregnancy.

The actual duration of the sterility interval in mouse, monkey, chimpanzee, and man, would appear to be respectively, one month, twelve months, four to thirteen months, and three years. Variability in respect of the duration of this period is, of course, the rule, but the precise limits of this variability in any of these groups

remains to be determined; nonetheless, it is clear that in the chimpanzee, as in man this variability is quite appreciable. In about 25 per cent of mice conception is possible at first oestrous, but in the macaque it has not been recorded; it is, however, not altogether unlikely that in some macaques conception is possible at first oestrous, although one year seems to be the normal interval between first oestrous and first conception. In man the observations of anthropologists and gynecologists would indicate that the interval between puberty and nubility is, on the whole, of about three years duration; but the variability in the human species in this, as in other respects, is apparently very considerable, and it is probable that genetic differences, expressed in differences in the duration of the interval, exist between different local groups of mankind.

That a period of adolescent sterility normally exists in most human females is a fact substantiated as much by the observed phenomenon, as by the nature of the physiological processes involved in the maturation of the reproductive system; this evidence alone strongly suggests that during early adolescence the organism must, in most cases, necessarily be sterile.

The fact that the existence of such a period of infertility in the post-pubertal adolescent girl has escaped the attention of most human beings is not as difficult of comprehension as may at first appear. How the belief that the first menstruation represents a token of the girl's arrival at the procreative stage of development came into being it is impossible to tell. It may be that it had been independently noted in various human groups that women remained sterile as long as they had not reached puberty (the first menstruation), that after puberty women

menstruated periodically, and that during their menstrual life alone were they capable of bearing children; for after the final cessation of these periods (menopause) they were again sterile. Women capable of menstruation were therefore considered to be capable of child-bearing. Hence the appearance of menstruation was taken to be the sign of the ability to procreate. The inference is certainly a logical one, but it is not wholly true, and unless the conditions are such as to make the observation a simple matter there is no possible way in which the falsifying factors in this inference would become apparent to sense. Since these conditions do not, in most human societies, exist,

it is practically universally believed that the first menstruation is a sign of the ability to procreate. We have shown that there is good reason to believe that this is not the case.

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THE PROCESSES OF EVOLUTION

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UNTIL the appearance of Darwin's *Origin of Species* in 1859, the idea of organic evolution was by no means an established factor in biological thought. The instability of species had been suggested more than once and definite systems of evolution had been formulated by some writers, but it remained for the tremendous weight of evidence presented by Darwin to make a permanent impression on the scientific world.

There is a valuable lesson in this fact. In the modern scientific world we are prone to be impressed by bulk, especially when it is the bulk of extensive experimental evidence. Just as definitely are we prone to discount a purely logical analysis of any topic. The weakness of the position should be evident, but unfortunately it seems often not to be, for masterly summaries of experimental data continue to arouse admiration and we continue to follow the trails that they blaze even when logical analysis points elsewhere. Darwin's own contribution and the corollaries added by Weismann and others have themselves demonstrated this weakness, for through able support Darwin gained for the partly fallacious theory of natural selection a degree of acceptance that has since proved wholly unjustified, and any corollary that could be seized upon for the support of this position has been used, whether logical or illogical, established by experiment or wholly without such evidence. Our reasoning in evolution has very definitely shown the frailties

of human prejudice, as well as the beauty of precise scientific thought.

It seems wholly beyond question that the attention of biologists to evolution should now be concentrated on the cold logic of the problems involved, in the expectation that the remaining gaps in our evidence might thus be made clear and subjected to sound experimental investigation. Instead the principal trend seems to be a rhetorical denial of the views that have been either neglected or difficult to investigate, and a positive argument for the views that have found favor, even to the extent of maintaining that the vital gaps in the supporting evidence are not insurmountable, since there is still possibility of their being filled! To argue that possibilities on one side of a question are not to be considered because experimental proof is lacking, and that possibilities on the other side are to be accepted in spite of lack of evidence because they are logical possibilities involves a naïveté that one would scarcely expect in scientific writing.

The writer's attention has been drawn again to this question primarily by Dobzhansky's *Genetics and the Origin of Species*, a magnificent contribution to the literature of evolution, even though, unfortunately, it is guilty of the faults just mentioned. As a discussion of the subject indicated in the title, it is certainly the finest yet produced, but its very fineness endangers the general consideration of evolutionary processes by minimizing all factors that cannot be encompassed by such a title.

When, in addition, the reader encounters such statements as this:

"As to the direct adaptation, experimental data give no support for believing that such a thing exists. This question has been discussed almost *ad nauseam* in the old biological literature, . . . we may refrain from the discussion of it altogether." (P. 31.)

he will certainly not be influenced toward a broadly unbiased view. Another statement made previously on the same page is as follows:

" . . . the nature of the mutational changes in the genes remains unknown. This is, of course, neither surprising nor discouraging, for an understanding of the nature of mutations presupposes a knowledge of the nature of the genes as such, which remains as yet one of the distant goals of genetics."

Such an attitude arouses grave suspicion that still another statement (p. 186) may come home to roost, viz., that " . . . the 'theories of evolution' arrived at by different investigators seem to depend upon the personal predilections of the theorist."

Within the scope of such a brief paper as this it is obviously impossible to comment point by point upon the materials of an entire volume. Indeed, no need for such comment exists in the writer's mind for he accepts the work in general as has been stated above. As for his own detailed attitude, it was expressed in *The Problems of Evolution* (1931) in sufficiently general terms to permit brevity and inclusiveness, and nothing published in the interim has shaken the analysis then expressed. However, three years of work in the study of an insect species which were wasted so far as its relation to the process of evolution is concerned, have developed a very vivid appreciation of the difficulties that will beset the biologist who wishes to undertake the program of investigation recommended in this book. In the course of their long evolution, existing species have gained a remarkable

degree of autonomy. It will evidently not be a simple matter to find a form that is favorable for the experimental study of the neglected phases of evolutionary change.

For brief comment, the evolutionary *impasse* may be concisely expressed as the old controversial matter of hereditary variations versus acquired characters. The terms are not well taken, but they persist from the older literature and serve as convenient labels. In the strict sense, the acquired characters of evolution may be defined as the expression of hereditary potentialities in the individual according to specific conditions of its environment. It has been abundantly demonstrated that no evidence of such individual reaction is to be found in the next generation save when it appears again in association with the same environmental conditions. As to hereditary variations, the acceptance of a hereditary genetic complex leaves us with no explanation of the very foundation of evolution, viz., the origin of differences. Darwin and his followers erred in this detail, Lotsy erred here also in his work on hybridization, and modern geneticists have either fallen short of an explanation of evolution or have committed themselves to the extremely narrow concept of origin through the influence of radiation.

Assuming the correctness of the basic concept of modern biology that living substance was originally a homogeneous mass, the acquisition of diversity permits no assumption of previous diversity. It is possible and logical to argue, as the writer has done (*op. cit.*, pp. 178-179) that in the existence of such a primordium the only variable factor is the environment, and that the impact of environmental fluctuations on the living substance must have been the initial source of change through the resulting varied reactions of

this substance. The opinion seems so clear that it should clarify our approach to the whole subject, but unfortunately the modern world fails to provide us with primordial living matter for experiment.

Certainly the development of any living substance through the ages, however simple or complex it may have been in the beginning, could have taken place only if it possessed or acquired the power to exist in harmony with a fluctuating environment, so that today we are faced with an extremely variable living world in addition to the variable environment as the field in which we must work.

In this field we witness hereditary changes in the organism and label them mutations without knowing just how they arise. We also witness the remarkable plasticity of living things in meeting the fluctuations normal to their environments, and in some cases we see in them visible results of their reaction to environmental stimuli. These results are an expression of hereditary potentialities. They do not persist in the heritage. The effect of such responses upon the hereditary potentiality has not yet been satisfactorily investigated, but it appears to be the only significant point of attack on this problem. We know that a functional capacity increases in the individual as it responds to persistent and increasing stimulus, but whether the offspring of individuals that have undergone such development have any greater capacity for such a response than the original heritage would have provided, we do not know. We know also that the response of individuals may bring about results that resemble mutant characters, and that the two do not behave the same, hence the modern geneticist must dispose of these spurious imitations as phenocopies, lest they steal some of the glory of true mutations. Here again is a confusing situation.

The chief obstacle in these discussions seems to be the persistence of emphasis on individual responses or acquired characters that adjust the organism to the inciting environmental condition. The controversial pitting of this point of view against the adaptive adjustment of species through selective processes has been all too easy to maintain through the many years of argument over the nature of evolution. This antagonism is difficult to support when we admit the all-important principle that everything in the organism, great or small, adaptive or non-adaptive, structural or functional, results from the reaction of its heritage to its environment. If the body encounters a new condition, it responds within the capacity of the heritage and if it is incapable of responding to a significant environmental change, it perishes. In addition to directly adaptive responses like the tanning of the human skin, however, these reactions include many of a purely incidental nature, such as the varied colors and patterns of insects that occur in seasonal forms in response to varying light and humidity. All of these characters are evidence of the organism's capacity for change from its primary state, hence the evaluation of their evolutionary significance demands much broader concepts than the purely adaptive response of individuals to conditions of importance in their own vital reactions.

For many years it was a preferred attack among Neo-darwinian evolutionists to demand that their adversaries show how the reactions of the individual could possibly have any influence on the chromosomes or on the germ cells. It is quite evident that they are as much an expression of something already present in the hereditary complex as are any other characters of the individual. The real problem is to show whether or not the capacity of any gene for expression in the

developed characters of the body can be modified beyond its original limits through the exercise of that capacity in an unusual way or for an unusual period. Logically such a change is entirely in harmony with the expression of all vital functions, but it remains unproved.

Reference to the literature of modern genetics provides us with recent and significant statements of opinion on the variability of gene action. According to the prevailing concept of environmental response, anything external to the living unit under consideration is a part of its environment, and in the information now available on position effects such a relation is apparent. On this point Dobzhansky writes (p. 115):

"A rapidly growing amount of evidence indicates, however, that the genes are not quite so impregnable and impervious to the influence of their neighbors as has been thought. . . . A change of the linear order of the genes in a chromosome may then leave the quantity of the gene unaffected, and yet the functioning of the genes may be changed."

This interpretation is not extended beyond relation of the gene to its neighbors, but even in this degree it is an indication that the expression of the gene is conditioned by surrounding factors. Something outside of itself determines in part the action of the gene.

The further assumption that conditions in the cell beyond the confines of the nucleus may also play a part in the expression of the gene is so perfectly admissible on the basis of our modern knowledge as to follow without detailed discussion. There is nothing extraordinary about any of these points. Rather, they are harmonious details of the process of interaction with environment that is fundamental in all life. The only point that remains uncertain is their effect on the functional capacity of the gene as a

hereditary unit, and it is to an appreciation of the importance of this problem that this discussion is directed, not to the establishment of the personal predilections of the writer!

The poverty of experimental evidence bearing on this problem should be a warning in itself. Most investigations of individual reaction to environmental conditions have been limited to a few generations and none known to the writer has provided gradually increasing stimuli over a reasonably long series. The possibility of individual reaction to varied environmental conditions depends upon hereditary capacity for some latitude of response. If response out of the usual range can be demonstrated in one generation, there is no reason to suppose that the capacity for the usual response has been impaired. Quite the contrary, if capacity for an unusual response persists through generations of normal reaction, it is a definite proof that some latitude of hereditary processes will persist even though all possible degrees of expression are not realized.

Significant experimentation demands several conditions. First, an organism must be available that responds to some controllable and variable environmental factor with a visible bodily development. Second, the lethal degree of this variable factor must be ascertained, if it is of sufficient importance to the organism to have such an effect. For conclusive experiments this condition appears to be essential. Third, the environmental factor should be varied progressively little by little to determine how greatly tolerance can be increased in individual life. Fourth, a similar modification through a long series of generations should demonstrate whether or not the effects of individual response are cumulative through a hereditary series. In the case of non-adaptive

characters, the lethal point as an absolute test of the reactive capacity of the heritage is, of course, lacking, and the degree of response itself is the only measurable result of the changed environment.

As far as the writer knows, Woltereck's experiments with daphnids, Agar's with *Simoccephalus*, and Sumner's with mice are the most noteworthy experiments of this type. Although they lack some of the factors outlined and offer rather meager evidence, they gave results strongly suggestive of the transmission of some modification of hereditary capacity.

The possibility also exists that response to a specific environmental variation of small degree may not be a visible change in the organism, but that repeated impact of this condition may ultimately bring about a change. A further possibility exists of an immediate reaction in the soma or in the cytoplasm, and of an ultimate change in the genes as an adjustment to their changed surroundings. It is entirely probable that any such change would be non-adaptive—a purely incidental result of moderate chemical change in the living substance. As such it would apparently be hailed as another mutation, and the march of modern genetics would continue uninterrupted if the environmental factor persisted or the gene were actually changed.

In view of such possibilities no analysis of evolutionary processes can be complete and final until it disposes of the several questions raised. When we can bring experimental evidence to bear on the following points we shall be nearer to another step in evolutionary theory than we have been since the rise of modern genetics in the first decade of the century. We must know whether the response of the individual heritage is capable of influencing the capacity of the hereditary substance for like response. We must

know whether continued response through a series of generations is capable of influencing hereditary capacities so that they may ultimately be independent of the original causative environmental stimulus. Finally we must know whether the changes resulting from response to environmental conditions may gain significance in the life of the organism in relation to other factors in its environment, as was proposed by Cuénot in his theory of preadaptation.

From the point of view of the geneticist it is highly important to know also whether the gene mutations and other types of chromosomal change may become significant to the species as it maintains itself in nature or under an approximation of a natural environment. The *possibility* alone is of no more real value in the materials of evolution than the *possibility* of purely Lamarckian results.

It is unfortunate that biologists find it so difficult to leave behind them the prejudices of an earlier day in this field of thought. We are in grave danger of evading important lines of investigation because of the fear of being Lamarckian, and in equally grave danger of being drawn by the truly magnificent accomplishments of genetics into a false assumption of the adequacy of this science in the explanation of evolution. Surely it is time for us to be scientific here as in other matters, to classify both our facts and our hypotheses according to their merits with full recognition of the limitations and the promise of each, and to work efficiently toward the establishment or disproof of the uncertain points.

There can be no reasonable doubt that gene mutations, polyploidy, translocation, and all of the other corollaries of modern genetics have a place in evolutionary change. These factors, together

with selective and isolating processes in the environment, may well be of great importance in the evolution of the complex populations of the present. We cannot explain evolution as a basic process, however, without accounting for the origin of diversity in an originally homogeneous primordium, and when that

is done, diverse hereditary mechanisms themselves should prove to be resultants, not causes, of evolution. Whether the demonstration of this relationship can ever be satisfactorily accomplished with the complex mechanism as an inevitable part of the experimental material, remains to be proved.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

BRIEF NOTICES

EVOLUTION

THE ENVIRONMENT AND HISTORY OF THE TOROWEAP AND KAIBAB FORMATIONS OF NORTHERN ARIZONA AND SOUTHERN UTAH. *Carnegie Institution of Washington Publication No. 492.*

By Edwin D. McKee. *Carnegie Institution of Washington, D. C.* \$3.00 (paper); \$4.00 (cloth). 10 x 6½; viii + 268 + 48 plates; 1938.

This somewhat technical treatise covers the Permian deposits of the Colorado valley in Arizona and Utah. Formerly the Kaibab formation was called the Aubrey, but that latter name is now construed to include the Torowep as well, and the name Kaibab has come into use to designate the Aubrey in its original restricted sense. Below the Torowep lies the Coconino, a carboniferous deposit. Above the Kaibab lies the Triassic. Thus the Kaibab and the Torowep together include all the Permian rocks of this region. The Permian rocks are of course unconformable with those above and below them. Also the Kaibab and the Torowep are themselves separated by unconformity—but this unconformity is of a different type.

All the invertebrate phyla are represented among the fossils of these rocks, but only the brachiopods have been singled out for separate treatment. Of these, twenty-eight species are described, of which eight are new. Usually, in publications

of this sort, only the new species are described, the old ones being merely mentioned by name, but since the established species are the important ones in synchronization of strata, their descriptions are much the more helpful. The plan of describing all species as the author has done is much more acceptable, and it is only to be regretted that the entire animal kingdom has not been covered systematically.

The photographic plates are excellent, and the index and bibliography quite exhaustive.



PATTERNS OF SURVIVAL. *An Anatomy of Life.*

By John H. Bradley. *The Macmillan Company, New York.* \$2.25. 8½ x 5½; 223; 1938.

"If there is any meaning for mice or men in the restless drive of life, a billion years of living should contain it. To search those years for that meaning will be the object of this book." So writes Bradley (p. 5), remarking further (in something like an aside) that "part of the business of being human is to costume somber facts in pleasing fancies" (p. 21). Bradley has succeeded marvelously in his secondary purpose; the "facts" might not be recognized by their own fathers. As one of Bradley's fellow paleontologists

wrote recently in a review of his book, "his ideas are sure shots at the mark, and beyond." Indeed, they go beyond the beyond. Bradley retells the story of evolution, stressing theory to the almost complete exclusion of evidence, and reducing the speculative efforts of the leading evolutionists to picturesque if not astounding epigrams. Originally some of the chapters were published as magazine articles. In that form they would appear as they should—as metaphorical entertainment. Unfortunately, the meaning of life is not disclosed. As Bradley says, at the tip of his tale, "It is not for the historian of life to say. Self-directed evolution, so far as he knows, is an adventure without precedent in a billion years."



STUDIES ON CENOZOIC VERTEBRATES OF WESTERN NORTH AMERICA. *Contributions to Palaeontology, Carnegie Institution of Washington Publication No. 487.*

By Robert W. Wilson, John R. Schultz, Hildegard Howard, Edwin H. Colbert, J. D. Laudermilk, and P. A. Munz. Carnegie Institution of Washington, D. C. \$4.00 (paper); \$4.50 (cloth). 10 x 6½; 281 + 48 plates; 1938.

The following papers are herein presented: (1) New middle Pliocene rodent and lagomorph faunas from Oregon and California (19 pp., 3 plates), by Robert W. Wilson; (2) Pliocene rodents of Western North America (52 pp., 2 figs.), by Robert W. Wilson; (3) A late Cenozoic vertebrate fauna from the Coso Mountains, Inyo County, California (34 pp., 8 pls., 3 figs.), by John R. Schultz; (4) A late Quaternary mammal fauna from the tar seeps of McKittrick, California (104 pp., 17 pls.), by John R. Schultz; (5) The Rancho La Brea caracara: a new species (23 pp., 3 pls., 1 ch.), by Hildegard Howard; (6) Pliocene peccaries from the Pacific Coast region of North America (28 pp., 6 pls., 4 figs.), by Edwin H. Colbert; and (7) Plants in the dung of *Nesotherium* from rampart and Muav caves, Arizona (10 pp., 11 pls., 1 fig.), by J. D. Laudermilk and P. A. Munz. These studies, with their careful workmanship, excellent il-

lustrations and literature lists form a valuable addition to palaeontological literature of Western North America.



DIE PHYLOGENIE DER WIRBELTIERE AUF PALÄONTOLOGISCHER GRUNDLAGE.

By Oskar Kubn. Gustav Fischer, Jena. RM. 4.50. 9½ x 6½; viii + 94; 1938 (paper).

This is a brief but complete summary of paleontological data concerning the phylogenetic histories of the vertebrates. As is the usual procedure with works on this subject, the author begins his story with the Agnatha and ends it with the primates. The author does not herein subscribe to any theory of descent, but merely attempts to present—by sorting out the more important findings of the tremendous volume of literature, especially that of the last decade—a factual picture of the origin and development of the vertebrates.

Seventy-seven excellent illustrations are included in the 92 pages of text. There is an index of subjects.



MIOCENE AND PLIOCENE FLORAS OF WESTERN NORTH AMERICA. *Contributions to Palaeontology, Carnegie Institution of Washington Publication No. 476.*

By Ralph W. Chaney, Maxim K. Elias, Erling Dorf, Daniel I. Axelrod, and Carlton Condit. Carnegie Institution of Washington, D. C. \$3.00 (paper); \$4.00 (cloth). 10 x 6½; 272 + 27 plates; 1938.

The following papers, which will be of much interest to palaeobotanists, are included in this volume: Late Tertiary floras from the high plains, Ralph W. Chaney and Maxim K. Elias, with a chapter on the Lower Pliocene vertebrate fossils from the Ogallala Formation (Lavern Zone) of Beaver County, Oklahoma, by Curtis J. Hesse (pp. 72, 7 plates, 11 text figures); A Late Tertiary flora from southwestern Idaho, Erling Dorf (pp. 51, 3 plates, 2 text figures); A Pliocene flora from the Mount Eden beds, southern California, Daniel I. Axelrod (pp. 58, 6 plates, 1 text figure); The Deschutes flora

of eastern Oregon, Ralph W. Chaney (pp. 31, 7 plates); The San Pablo flora of west central California, Carlton Condit (pp. 51, 7 plates, 1 text figure).



DIE ENTSTEHUNG DES LEBENS durch Stetige Schöpfung.

By Ignaz Lichtig. N. V. Noord-Hollandsche Uitgevers Mij., Amsterdam. (Obtainable in America from Nordemann Publishing Co., New York. \$4.15.) H. Gulden 6. (paper); H. Gulden 7.50 (cloth). 10½ x 7½; xx + 371; 1938.

The author argues for the "continuity" theory of the origin of life, reasoning at length from biology, morphology, ontogeny, paleontology, stratigraphy, biogeography, and paleoclimatology. According to his view living matter first originated from inorganic substances about 1500 million years ago and the different forms of life developed rapidly and phylogenetically.

The bibliography includes 235 titles. There is no index.



FOSSIL ANTHROPOIDS OF THE YALE-CAMBRIDGE INDIA EXPEDITION OF 1935. Carnegie Institution of Washington Publication No. 495.

By William K. Gregory, Milo Hellman, and G. Edward Lewis. Carnegie Institution of Washington, D. C. \$1.00 (paper); \$1.25 (cloth). 10 x 6½; 27 + [1] + 8 plates; 1938 (paper).

Specimens of fossil ape teeth and parts of jaws secured by the Yale-Cambridge India Expedition have aided the authors in tracing the phylogenetic development of these early simians. All the specimens collected are described in the text, and eight plates of photographs supplement these descriptions. The authors conclude that the extinct anthropoid apes ranged over an enormous area, that the group as a whole was exceedingly variable, and that the Siwalik genus *Ramapithecus* and the South African genus *Australopithecus*, while still simian by definition, were almost at the human threshold.

GENETICS

THE GENETICS OF SCHIZOPHRENIA. *A Study of Heredity and Reproduction in the Families of 1,087 Schizophrenics.*

By Franz J. Kallmann. With the Assistance of Senta Jonas Rypins, and with an Introduction by Nolan D. C. Lewis. J. J. Augustin, New York. \$5.00. 9½ x 6½; xvi + 291; 1938.

This thorough, factual study of genetic factors in the schizophrenic psychosis is based on 1,087 schizophrenic patients admitted to the Berlin-Herzberge Hospital between 1893 and 1902, 3,279 parents, husbands and wives of patients, 3,384 direct descendants, 3,920 siblings and half-siblings and 2,194 nephews and nieces. The patient material was divided into the four diagnostic categories: hebephrenic, catatonic, paranoid and simple, the two former divisions being grouped as "nuclear" schizophrenia and the two latter as "peripheral" schizophrenia. The nuclear group was found to have a lower fertility and a higher incidence of taint among their descendants than the peripheral group.

The problem of eugenic prophylaxis is considered in a practical way and the conclusion reached that sterilization of schizophrenic patients is an unjustified and inadequate means to the desired end of decreasing the incidence of schizophrenia to a significant extent in succeeding generations. The author feels that the facts fully support the importance of hereditary predisposition for the development of the schizophrenic psychosis, finding that it appears as a recessive trait and that the majority of cases originate through heterozygotic taint-carriers in the patient's collateral lines. The eugenic procedure recommended by the author, namely wide-spread limitation of marriage and propagation in all schizophrenic symptom-carriers at the beginning of their reproductive period, and in all heterozygotic taint-carriers and the homozygotic transmitters with masked and latent traits, is, in its entirety, beyond present-day diagnostic acumen. However, a beginning can be made in educating patients, particularly border-line cases who are most apt to marry, against propagating.

The incidence of tuberculosis in this material was investigated and a striking correspondence found between expectation of schizophrenia and mortality from tuberculosis. The results in this respect are so unequivocal that they can only be interpreted as actual gene-coupling of the tendency to schizophrenia and the heredito-constitutional susceptibility to tuberculous infection. It is suggested that the decisive factor in the genesis of schizophrenia and tuberculosis is a hereditary inadequacy of certain tissues, possibly the reticulo-endothelial cell apparatus.

The volume concludes with a glossary of abbreviations and of genetic terms, an index of tables, an index of names, and an excellent bibliography. An important book.



GENETIC RELATIONS OF SOME COLOR FACTORS IN LETTUCE. *United States Department of Agriculture Technical Bulletin No. 620.*

By Ross C. Thompson. *Government Printing Office, Washington.* 20 cents. 9 x 5½; 37; 1938 (paper).

Only brief mention can be made of some of the findings of this study:

The genetics of the inheritance of anthocyanin pigment in the leaves of lettuce was studied in progenies from 16 crosses involving 9 different homozygous genotypes. Seven genes were found to be necessary to account for all of the segregations obtained in the F_2 and F_3 progenies.

Three genes, R/r , form a multiple allelomorphous series controlling the intensity and pattern. The presence or absence of anthocyanin was found to be controlled by two complementary factor pairs, C and T .

The multiple allelomorphous series R/r and the allelomorphs C showed linkage with 36 percent of recombinations.

In the text are illustrations and tables and the work concludes with a list of 29 titles.



NEUE GESICHTSPUNKTE IN DER VERERBUNG.

By August Bier. *Verlag von Julius Springer, Berlin.* RM. 3.60. 7½ x 4½; [4] + 70; 1938.

In the journal *Züchter* the author, a physician, had recently published some articles on his success in producing the blue lupine (*Lupinus angustifolius*) and the perennial lupine (*Lupinus polyphyllus*) from seeds of the annual *Lupinus luteus*. These received some adverse comment, so in this book Bier describes his experiments, with seeds of known origin, in greater detail and answers some of the objections. This new method of inheritance (the exact mechanism is not known) he has designated by the term "transmutation." He includes also in this book some discussion on the reversion of domesticated plants and animals to the wild type when given the opportunity. This work is well documented, but there is no index.



THE GENETICS OF THE PIG. *Reprinted from Bibliographica Genetica XII.*

By A. D. Buchanan Smith, O. J. Robison and D. M. Bryant. *Martinus Nijhoff, The Hague.* Gld. 8. 9½ x 6½; 160; 1938 (paper).

This paper, issued from the Institute of Animal Genetics of the University of Edinburgh, discusses the color, hair and skin, physiological characters, disease resistance, mental traits, sex, abnormalities and defects, and anatomy and conformation of the pig, in the first 82 pages. Then follow sections on the productive qualities (20 pp.) and methods of improvement of the breeds (15 pp.). Both the geneticist and the practical breeder will find much of interest in these pages and the lengthy literature list (27 pp.) invaluable. A group of illustrations and subject and author indexes conclude the study.



GENERAL BIOLOGY

METHODS AND MATERIALS FOR TEACHING BIOLOGICAL SCIENCES. *A Text and Source Book for Teachers in Training and in Service.* First Edition.

By David F. Miller and Glenn W. Blaydes. *McGraw-Hill Book Company, Inc., New York.* \$3.50. 9 x 6; xii + 435; 1938.

This excellent text and source book for teachers and teachers in training has been written in direct response to a need frequently expressed by teachers of and teachers in training for elementary courses in the biological sciences. The four aims of the text are: (1) to encourage teachers to abandon the all too common method of book-teaching with little use of materials; (2) to assist the teacher in locating, securing, or culturing living materials at little expense; (3) to suggest how these materials may be used in classroom demonstrations and student projects and to explain how to set up simple homemade and inexpensive apparatus; (4) to foster through suggestion the use of the problem and project method so that the student will get practice in using his biological information in the understanding of principles and the application of these principles in his daily life.

The work covers particularly those questions frequently asked by student teachers on the problems of biology teaching. There is a general and representative bibliography.



LIFE IN AN AIR CASTLE. *Nature Studies in the Tropics.*

By Frank M. Chapman. Drawings by Francis L. Jaques. D. Appleton-Century Co., New York and London. \$3.00. 8½ x 5½; xii + 250 + 31 plates; 1938.

This is a completely diverting book—it is the kind one wishes to share immediately with a congenial friend. Barro Colorado is the largest island in Gatun Lake, and the Institute for Research in Tropical America has here carried on its studies of flora and fauna since 1923. Dr. Chapman settles down each year (1938 being his twelfth season) in this natural laboratory to a period of intensive, but patient and leisurely observation of his strange neighbors which include many rarely seen tropical birds, monkeys, coatis, opossums, kinkajous, peccaries, turkey buzzards, and parrots in their jungle habitats. He describes the songs and calls of the birds in the trees near his balcony, and also the characteristics of the birds of the tropical waters. *Life in an Air Castle* is a sequel to the naturalist's earlier volume entitled

My Tropical Air Castle. These two books constitute a remarkable record and will delight the layman as well as the bird lover and botanist.

The text is illustrated with photographs by the author, and drawings by Francis L. Jaques. There is a very helpful list of reference books, as well as a list of the birds of Barro Colorado, and a satisfactory index of five and a half pages.



BIG FLEAS HAVE LITTLE FLEAS or Who's Who Among the Protozoa.

By Robert Hegner. Williams & Wilkins Company, Baltimore. \$3.00. 10 x 6½; vi + 285; 1938.

Growing out of a series of six lectures delivered before a general audience (Messenger Lectures, Cornell University, 1937), this book is distinguished among books of its kind. Indeed, in the manner of its presentation, it is unique. Combining scientific exactness with the attractiveness and readability of "Ferdinand," Hegner introduces the protozoa in a way which will appeal at once to the protozoologist, to the young student who is just discovering microscopical life, and to anyone else who is curious about living things. Taxonomy becomes the "Parade of the little millions," while the control of malaria is dealt with in a chapter called "Conquistadors." Between these topics one finds discussions of typical life cycles, parasitism, the evolution of new forms, the effect of diet on man's "inner life," etc., told as the adventures of that mighty hunter, the protozoologist, armed with his trusty microscope.

Hegner's book is not a textbook, yet it seems destined to be used as a text in many a classroom. It presents first-hand knowledge in a lively, conversational style, both in prose and in verse, and is illustrated with good photographs and drawings, serious and otherwise.



WILD NATURE IN AUSTRALIA. *Wonder Animals and Birds.*

By Charles Barrett. Robertson and Mullens, Melbourne. 2s. 6d. 9½ x 7½; 56; 1938 (paper).

Australia is indisputably the land of marvels; a fact which is amply attested by this fascinating little book. Why evolution should have singled out the lone island continent of Australia to go on a spree in ages past is still a mystery to the most learned naturalists. Barrett has devoted much of his life to a study of the natural wonders of Australia, and has attempted in many ways to create in man an appreciation of these wonders to the end that they may be preserved in their natural state for all posterity. His book is a delightful pictorial record of some two dozen animals and plants native to Australia, together with the scientific name and characteristic habits of each form. The following are some of the forms described: the lyre, the bower and mound-building birds, fairy penguins, the kookaburra, the emu and the cassowary, platypus, echidna, giant earthworms (12 feet long in rare cases), wombats, tree-ferns; and seabird "cities" and white ant citadels.



ADVENTURES WITH LIVING THINGS. A General Biology.

By *Elsbeth Kroeber and Walter H. Wolf*.
D. C. Heath and Co., Boston and New York.
\$1.96. 8 x 5½; xiii + 798; 1938.

Fundamental biological concepts are well brought out in this text for secondary school students. The ideas are clearly presented in such a manner that the language and subject matter increases in scope and difficulty along with the students' growing ability to comprehend. The first part of the volume introduces the phyla and classes of plants and animals. The second section deals with metabolism, behavior, and reproduction; the third treats of biological generalizations involving similarity, variability, heredity, environment, and evolution. Questions and experiments are suggested to supplement the reading.

Interestingly written, the book contains many brief sketches of the lives and noteworthy experiments of eminent biologists.

PHYSICAL GEOGRAPHY AND GEOLOGY.

By *L. Dudley Stamp*. Longmans, Green and Co., New York and London. \$1.75.
7½ x 5; vii + 256; 1938.

A good impression of methods of topographical formation could be obtained by glancing at the photographs in this book. These pictures are supplemented by numerous drawings and climatic maps. Most of the examples used were known to the author personally, but what has been a gain to the reader in this respect has been a loss in the confinement of the material almost exclusively to the British Isles and India. Hence the work is far more suitable for English students than for those of the United States or Canada.

An attempt to show relationships between geology and biology falls short of what the biologist would like, especially in that section dealing with the history of the earth. However, this does not impair the value of the book as a physical geography text.



PROCEEDINGS AND TRANSACTIONS OF THE LIVERPOOL BIOLOGICAL SOCIETY, Volume 51. Session 1937-1938.

Edited by *R. J. Daniel*, with the co-operation of *S. T. Burfield and W. S. Laverock*.
University Press of Liverpool. 1 Guinea.
8½ x 5½; ix + [3] + 70; 1938.

Reports on the following investigations are given in the second part of volume 51 of these "Proceedings": (1) The fauna of fixed and floating structures in the Mersey Estuary and Liverpool Bay, by James H. Frasier (pp. 1-21). This paper discusses the pollution, silt and debris in the water, and the varying salinity in relation to their detrimental effects on the fauna present. (2) The Manx Herring Shoals, by W. C. Smith (pp. 22-75). In this fishing region, three areas can be distinguished with characteristic classes of fish in each: an inshore ground, divided into a northern section (range of size of fish 22-26 cm., mode 23 cm.), and a southern section (24-28 cm., mode 26 cm.), and an offshore ground (26-29 cm., mode 28 cm.). The statistical material is arranged in 13 tables.

MANUEL CRITIQUE DE BIOLOGIE.

By J. Lefevre. Masson et Cie, Paris. 190 francs. 10 x 6½; 1048; 1938 (paper). This weighty tome is divided into five books, as follows: (1) the cell in general—cytology; (2) cells functionally differentiated—histophysiology; (3) nutritional and metabolic functions; (4) neural and sensory functions; (5) bioenergy—vital heat and the animal machine. It is based on the author's class lectures at the Laboratory of Bioenergetics, Paris, and emphasizes the necessity of developing critical faculties among readers and pupils in order that they may orient themselves in the chaos of contradictory theories and be prevented from taking as facts everything they see in "scientific" movies. There is an index but no bibliography.



PHYTOPLANKTON AND THE HERRING. Part III. Distribution of Phosphate in 1934-1936. Fishery Investigations, Series II, Volume 16, Number 3.

By Michael Graham. H. M. Stationery Office, London. 2s. (Obtainable in North America from British Library of Information, New York). 60 cents. 10½ x 7; 30; 1938 (paper).

A report of the survey of plankton and hydrology over the greater part of the southern North Sea during the summer and autumn of 1934, 1935 and 1936. Charts (on transparent paper) showing the phosphate concentration at one meter's depth accompany charts (by Savage and Wimpenny) showing the diatom (*Rhizosolenia*) patch. The author discusses the factors which favored the vast diatom concentration of 1934 and caused its more recent decline. Maps and figures accompany the report, also a reference list. The last four pages in the bulletin give a list of scientific publications on sea fishery investigations issued by the Ministry of Agriculture and Fisheries.



SEVENTY-FIVE YEARS. A History of The Buffalo Society of Natural Sciences 1861-1936. Volume XVIII.

The Buffalo Society of Natural Sciences,

Buffalo. \$2.00. 9½ x 6½; 204 + 53 plates; 1938.

This volume, published in celebration of the Buffalo Society of Natural Sciences' seventy-fifth anniversary and written by ten members of its staff, contains numerous chapters on the museum's special features and collections, as well as a history of the society and its plans for the future.



HUMAN BIOLOGY

RESEARCH MEMORANDUM ON POPULATION REDISTRIBUTION WITHIN THE UNITED STATES. Bulletin 42.

By Rupert B. Vance. Social Science Research Council, 230 Park Ave., New York. \$1.00. 9 x 6; xiv + 134; 1938 (paper).

RESEARCH MEMORANDUM ON MIGRATION DIFFERENTIALS. A Report of the Committee on Migration Differentials. Bulletin 43.

By Dorothy S. Thomas, with contributions by Rudolf Heberle, E. P. Hutchinson, Eleanor C. Isbell, Fritz Meyer and Svend Riemer. Social Science Research Council, 230 Park Ave., New York. \$2.50 (cloth); \$2.00 (paper). 9 x 6; xiv + 423; 1938.

CITYWARD MIGRATION: SWEDISH DATA.

By Jane Moore. University of Chicago Press, Chicago. \$2.00. 9 x 6; xix + 140; 1938.

The events of recent years resulting from the seemingly abrupt changes in the material well-being of the people of this country have served to focus more than ever the attention of students of social sciences on the need for adequate information about internal migratory movements. The two memoranda published under the aegis of the Social Science Research Council are a by-product of the increase of interest in the subject. Both of them contain critical discussions of the investigations done on the subject and outlines of feasible future research. In Bulletin 42, Vance examines the problem from the standpoint of the relation of economic opportunity to differential population increase. First he outlines the several aspects of the problem relating to variations in economic opportunity according to the regions of the country and proceeds then to consider differential increase of population, changes

in employment opportunity and capacity, and labor mobility.

Bulletin 43 is concerned with the problem from the standpoint of the demographic traits of the migrant as compared to the stable population. In addition to a survey of some of the information on age, sex, civil status, physical and mental health, and occupation of the migrant, this memorandum contains seven appendices. In these, the author and others present annotated references to English, America, and German studies, notes on German and Swedish statistics and on the methodology of fact-finding.

One of the questions about which both writers are greatly concerned regards the movement of population from rural to urban areas. A contribution on one aspect of this query is made by Jane Moore in her study based on the 1930 Swedish census data. The inquiry has for its purpose to determine the characteristics of the community of birth and of previous residence of a selected portion of the "in-migrant" Stockholm population. The results of the analysis bearing on this point are presented in the first section of the monograph. The author finds that in the sample examined the relative proportion of persons coming to Stockholm directly from rural and agricultural areas is less than that of migrants who, although born in such areas, have first moved to towns and mixed industrial and agricultural areas. In turn, the latter constitute a relative number inferior to the migrants who were actually born in urban places. In the second section are recorded the data on the education, civil status, and types of occupation of the group of migrants studied. The general conclusion reached by the author is that the economic factor alone is not sufficient to explain migratory movements but that there is besides a tendency to migrate to and from closely resembling types of communities.

Moore's study, while not conclusive, brings out one of the features about migration that neither Vance nor Thomas has taken into sufficient account. It is that migration, whether internal or otherwise is not merely an economic phenomenon but is also a psychobiological one.

It would seem therefore that, as for population problems in general, the problem of migration will be sufficiently clarified only if due importance is given to its biological aspects.



NEW HORIZONS FOR THE FAMILY.

By Una Bernard Sait. *The Macmillan Co., New York.* \$4.00. 9½ x 6½; xiii + 772; 1938.

The author of this treatise is a professor of philosophy and so it is not surprising to find that the main purpose of this work is "to develop a broad philosophy of the family" and that the subject is presented on such a large canvas. The first part of the book is historical and discusses the status of the family in terms of social organization, religion, economics, sex, and education. The second part is on the contemporary family and is concerned mainly with the problems of education and welfare of children, the status of women, birth-control, and marital conflicts. The third and last part regards the problems of homemaking, financial and otherwise. The most striking features of the book are the great erudition demonstrated by the author and her eloquent style. She recognizes that this is a period in which the traditional inter- and intra-familial relationship patterns are undergoing alteration and she hopes that the future will see the development of the cooperative family. So far as can be understood this means the application of Dewey's type of liberal philosophy to intra-marital relations. Anyhow, the author hopefully envisions the future in the following terms and in her characteristic style:

In a family which is genuinely coöperative, the relationships between father, mother, and their children may once again become a radiating source of sympathy and understanding, in widening circles of social relationship. For the *care of life*, which in all ages has been the central preoccupation of women, is now recognized as the most vital concern of society. The spirit of motherliness, utterly opposed to force and violence, is found invaluable in human affairs. As more women become emancipated from ignorance, idleness, and the bonds of tradition, we may hope for fuller integration of scientific knowledge in the interests of human relationships, and for the shaping of new instrumentalities of social control.

But, as the spirit of motherliness is needed in the life of the world, so is there need for a fuller participation of men in family life—for a more intensive fatherliness. Manliness with its emphasis on protective strength, reliability, and courage is the correlative of womanliness, from which all trace of immature dependence has gone, but where the emphasis is still upon the qualities conducive to the care of life. Where manly men and womanly women also become developed human beings, the coöperative family will more fully emerge as the prevailing pattern of family life. Only then will its consequences for individual happiness and social well-being become apparent.



AFRICA'S GOD. X. Conclusion. *Anthropological Series of the Boston College Graduate School*, Vol. III, No. 3.

By Joseph J. Williams, S.J. Boston College Press, Chestnut Hill, Mass. \$1.00. 9½ x 6½; 46; 1938 (paper).

Part X summarizes briefly the data included in Dr. Williams' nine previous publications which have been reviewed in earlier numbers of this journal and have dealt with religious beliefs in Africa in the following geographical sequence: (1) Gold Coast and its hinterland, (2) Dahomey, (3) Nigeria, (4) French West Africa, (5) Congo and Angola, (6) Uganda, (7) East Africa, (8) Rhodesia, and (9) South Africa. The conclusions reached concerning these beliefs are that the religion of Africa is at present or has been at some time in the past monotheistic and that Hebraic contacts have played an important part in the religious beliefs and customs of the African tribes. Though the belief in a Supreme Being has, in many cases, been overshadowed by a heterogeneous and often incoherent animism, nevertheless there is a clearly defined monotheistic concept.

The author states that, in opposition to the theory of the classical evolutionists that African tribal religion has gradually risen from polytheism to monotheism, his own findings point rather to "a general retrogression in matters of religion and even where tribes have been polytheistic in recent years, there is often a clear indication of monotheistic belief in earlier days." Concerning the subject of Hebraic contacts, the author writes that "The presence of Hebrewisms throughout

the length and breadth of Africa leads one to suspect that the monotheistic cults of more recent times are due to an infiltration of Hebraic stock at an earlier stage in the development of the African Tribes."

Part X, like the previous numbers, includes many specific examples of Hebraic customs to be found in the various tribes, interesting facts concerning the different cults of worship, such as ancestor worship, demonology, ophiolatry (serpent worship), etc. and many other bits of information that could only be observed by people living in long and close contact with the peoples of Africa.

Following Dr. Williams' research there is an article on the Ghassulian flint industry in Tell 3, level IV, of Teleilat Ghassul by J. W. Murphy, S.J., who, in the last issue, reported on the pottery findings in this same ancient site.



DAHOMY: *An Ancient West African Kingdom. In Two Volumes.*

By Melville J. Herskovits. J. J. Augustin, New York. \$12.00. 9½ x 6½; Vol. I, xxi + [1] + 402; Vol. II, xiv + [2] + 407; 101 plates; 1938.

As the author well emphasizes, the study of native life in Dahomey presents a number of points of great interest and importance. In the first place, the social behavior pattern of the people and the political organization of the country (aside from very recent changes) represent a stage of social evolution unique among primitive African peoples. In addition, the civilization of Dahomey until a few years ago had been probably less affected than that of any other African territory by contact with the whites. It can be assumed then that a better understanding of the social behavior of other primitive peoples can be acquired from a study of Dahomey. With this view in mind and also in the hope of clarifying certain questions on the original social background of the American Negro, the author presents here the results of his personal visits to that country. He begins by examining the economic life of this group, that is to say, the production and distribution of goods and wealth, taxation and other

group regulations involved in the business of earning a living. There follow chapters on social organization that contain accounts of the kinship relations with emphasis on the highly complicated system of sib organization and the cult of the ancestors. Then, there are chapters concerning social behavior in relation to all phases of the individual development from birth through puberty, marriage and death. In the second volume, the author treats of the political organization and gives a most thorough and explicit account of the religious aspects of Dahomean culture. The final chapters deal with the art-forms developed in that country. The book contains also a sufficient if not exhaustive bibliography and there are a few interesting illustrations of the natives and some beautiful reproductions of local art. The majority of the information reported consists of first-hand observations and these have been well integrated with the more important previous studies on the subject. In this respect the one objection that could be raised is to the tendency to quote verbatim and at too great length passages from earlier writers. Except for such insertions, the book is written in a style that is straightforward and clear. With this work, Herskovits has made a definitive and lasting contribution to anthropology and ethnology.



FRANCE FACES DEPOPULATION.

By Joseph J. Spengler. *Duke University Press, Durham, North Carolina.* \$3.00. 9 x 5 $\frac{3}{4}$; xi + 313; 1938.

As early as 1325 France attained the demographic hegemony of Europe; about 1650 France reached her period of relative demographic dominance; in 1800 France had a population exceeded only by that of Russia; prior to and especially after 1850 the population of France grew less rapidly than that of other European lands and in 1850 France found herself stripped of the demographic hegemony of Europe. Moreover, "low natality and not high mortality was and is primarily responsible for the steady diminution in the rate of population growth in France."

In this monograph, the author traces the history of population growth in France, the changes in the geographical and occupational composition of the population, the history of natural increase during the years 1650-1935, the changes in differential natality and fertility and the history of the depopulationist fears which were expressed as early as the fourteenth and fifteenth centuries but were never so intensive as the alarm at the post-1800 decline.

The author also outlines the French explanations of the causes of the decline in natality and the policies and measures taken by the government to counterbalance the effects of low natality and to promote natural increase. Finally, the author analyzes the probable consequences of French population trends and appraises the measures for the promotion of population growth. In this last part, the author deals with the relationship of population growth and the economic welfare of the individual and the masses.



COBBERS. *A Personal Record of a Journey from Essex, in England, to Australia, Tasmania and some of the Reefs and Islands in the Coral Sea made in the Years 1930, 1931 and 1932.* New Edition.

By Thomas Wood. *Oxford University Press, London and New York.* \$2.50. 7 $\frac{1}{4}$ x 4 $\frac{1}{4}$; xv + 288; 1938.

The genuinely friendly character of the Australian people prompted the title of this book (cobbler = Australian slang for companion or mate). The author states in the preface that "this is not a guide book," nevertheless, those who are contemplating emigrating to Australia or visiting the continent should read it. In so limited a space we can only give brief extracts of some of the general comments offered.

Your bush, your wheat belt, your mulga scrub, your saltbush plain are great tracts of country, every one a matter for days in a car. You cannot give a glance and look for something fresh round the corner, for round the corner is just the same as where you are now. The mountains and the foothills, the tropical north, and, above all, Tasmania, change quicker: offer, like the English scene, better foreground country; but Australia as a whole gives bulk, not samples.

As with country, so with climate. "It never rains but it pours." . . . And it does not pour often enough. Floods are bad, but they are only one of the farmer's troubles. Drought is worse.

The easy optimism which the author found generally throughout Australia has, in his belief, its origin in (a) the climate, which is "mostly gloriously sunny and warm"; (b) the "give-it-a-go" attitude "which results in many jobs left unfinished" and (c)

this country of great distances does not necessarily breed great minds. It tends, on the contrary, to breed narrow ones. Here is another generalization far away from the whole truth, though near enough to a part of it. I have met throughout Australia men who were as well-informed and as imaginative as any one could wish for; but they are not typical. A great many of their countrymen made me feel that I was talking to precociously alert and self-satisfied children; and that I was an old, old man.

Australia is said to be "ninety-eight per cent British" yet the author found it unexpectedly cosmopolitan. An interesting trip was made to Phillip Island (50 miles from Melbourne)—a reserve for seals, penguins, mutton birds and the very charming native bears, the koalas.

The volume has a useful index. We wish that a map had been included.



HEALTH AND UNEMPLOYMENT. *Some Studies of Their Relationships.* McGill Social Research Series: No. 7.

By Leonard C. Marsh. In Collaboration with A. Grant Fleming and C. F. Blackler. Oxford University Press, New York. \$3.00.

8½ x 5½; xxv + 243; 1938.

That there are direct relationships between the statistics of employment and of the prevalence and duration of illness, the authors of this volume do not doubt, though they expressly point out that this is an assumption unverified by any sufficiently extensive study. Yet most readers will agree that the following statements are strong probabilities:

When the family income falls below a certain level, the standard of living declines rapidly. A small sum to spend on food usually means lack of fruit, fresh vegetables, milk and fats. Inadequate footwear and clothing increases the liability to colds and other ailments. Families move to low-rent areas or 'double-up' to economize on rents, resulting

in overcrowding, which is one of the worst evils of bad housing so far as physical health is concerned. Perhaps the worst sufferers are the 'new poor,' for they lack experience in living to the best advantage at low economic levels, and, in addition, their mental health is seriously jeopardized by the severe crisis through which they are struggling to make an adjustment. In the face of widespread unemployment, members of the lowest wage classes particularly find themselves without the means for health expenditures, apart altogether from the bare necessities of life.

This book does not pretend to be a complete survey of health conditions among the unemployed. It is but one series of detailed studies, based on Canadian surveys, and involving both adult and immature persons, which presents evidence in support of the statements quoted above, and which ends with a discussion of medical provision for the unemployed. The authors anticipated that their studies would "soon be superseded by wider health surveys or governmental statistical enquiries," but this has not been the case, hence the present studies are published on their own account, "in spite of their limitations."



PICTURE-WRITING OF TEXAS INDIANS. *The University of Texas Publication, No. 3809, March 1, 1938. Anthropological Papers, Volume II. Bureau of Research in the Social Sciences Study No. 27.*

By A. T. Jackson. *The University of Texas, Austin.* Free. 10½ x 6½; xxv + 490; 1938 (paper).

Just exactly what the early American Indian was trying to express when he painted or carved the strange figures which occupy the walls of numerous rocks, cliffs and caves of our western states, we shall probably never know. A popular theory has had it that the picture writing represented nothing more than the activities of an idle pastime. Jackson's study of the picture writing of the Texas Indians proves this theory entirely fallacious, and points out that the relics of Indian art are of enormous value in reaching a sociological or a psychological interpretation of early American cultures. The majority of materials for this study were found in about 30 counties

which make up the southwest corner of the state of Texas. It is interesting to note that the picture writings are not evenly distributed but according to the topography and geography of the land. Just the right surfaces have been selected in each case for the pictographs and petroglyphs, and the area where such surfaces are absent are devoid of any of the art. The point in emphasis throughout the volume seems to be that unless the present destruction of valuable sites of prehistoric art by vandalism is arrested, another decade or two will see the complete obliteration of much of the worthwhile picture writing, and with it the vanishing of much valuable history concerning early American man.

The text contains 324 maps showing the distribution of various forms of picture writing, (283 photographic figures), a bibliography of some 140 titles, and an index.



MARGARET SANGER, *An Autobiography*.

By Margaret Sanger. W. W. Norton and Co., New York. \$3.50. 9½ x 6½; 504; 1938.

Margaret Sanger's own account of her busy career and the history of birth control is here given in a lengthy detail which is neither tedious nor monotonous. With a skilled pen, a sense of both the humorous and the tragic, and a keen sympathy for those with whom she comes in contact, this crusader relates the happenings of her turbulent life from early childhood. Even those well acquainted with her fight for birth control should find new interest in the reminiscences of the author's early days and in her vivid description of her unusual family and childhood in Corning, New York, where as one of eleven children it was early impressed upon her that large families and poverty go hand in hand.

The story of Mrs. Sanger's ceaseless crusading for birth control despite her tubercular condition, her battles with the government and her subsequent imprisonment in the State of New York for the principles for which she fought, are well known. But added to this her autobi-

ography contains many fascinating travel notes of the countries into which she was led by her research. She writes of starving post-war Germany, of over-populated Japan, of the wretchedness of China and India, of Russia, Holland, England and Ireland with a clarity which stimulates the imagination. The descriptions of the people she has met in these wanderings also lighten these pages with amusing character sketches, for in this volume Margaret Sanger gives us intimate glimpses into the lives of such figures as Havelock Ellis, H. G. Wells, Professor Hu-shih, Gandhi and many others.



BROWN SOUTH AFRICA.

By C. Ziervogel. Maskew Miller, Ltd., Cape Town. 7½ x 4½; 95 + [1]; [1937?]. This book is published, as the author states in the preface, "at the request of many friends and by the crying need for a book about the coloured people by a coloured man". It is a study of the conditions in South Africa after the coming of the Dutch and deals with the subsequent vicissitudes experienced by the non-Europeans following this arrival.

In order to show more clearly what is meant by Brown South Africa, the following summary of the history as presented by the author is in order. On April 6th, 1652, Johan von Riebeeck and his small crew of men arrived in Table Bay, South Africa, to set up a refreshment station for the Dutch East India Company. Their arrival marked the beginning of Brown South Africa and of White South Africa. The Dutch found two peoples in South Africa—the Hottentots and the Bushmen. The Company had ordered these Dutch settlers to placate the natives and placation was carried to the point of intermarriage. In addition, slaves from Madagascar, Mozambique, and Malay were imported to help the settlers, and the subsequent relations of these slaves with the half-castes and the whites appreciably swelled the already increasing numbers of "hybrid browns" or the so-called colored population of South Africa.

The author discusses in this book the

economic, political, and educational history and the national welfare of colored people in South Africa under Dutch and English rule. The picture that he draws of colored life in South Africa is not an attractive one, and the following quotation clearly defines the author's feelings concerning the lowly life of his people: "The non-European of the twentieth century resents the social injustice meted out to him, and is determined to take his place in the social life of the land of his fathers."



CINQUANTE SIÈCLES D'ÉVOLUTION ETHNIQUE AUTOUR DE LA MER NOIRE. *Études d'Ethnographie, de Sociologie et d'Ethnologie, Tome I.*

By *Alexandre Baschmakoff*. *Paul Geuthner, Paris*. 40 francs. $9\frac{1}{2} \times 6\frac{3}{4}$; x + 177 + [3] + 2 plates; 1937 (paper).

One of the controversial points in ethnology concerns the importance to be given to linguistics as a method of study of ethnic evolution. Many eminent students of the subject believe that it has little value but the so-called Japhetic school which has developed in the last thirty years from the work of Marr in Russia takes the position that for the purpose of prehistoric investigations linguistics has equal value with anthropology and archaeology. According to this viewpoint, by appropriate linguistic analysis it is possible to reconstruct the historical development of a region and the purpose of this book is to illustrate the application of the general method in relation to the history of the peoples who have inhabited the Caucasus, Southern Russia, and Asia Minor. The study is introduced by a consideration of the ethnic stock of the peoples that today inhabit these regions. The author proceeds then to a discussion of the history of the Cimmerii and Iranian Scyths, the origin of the Khazars and that of the Karaites and of the pseudo-Tatars of Yalta. One of the most important conclusions reached by the author is that the Karaites are the direct and relatively unmixed descendants of the ancient Tauri and that to a lesser degree the pseudo-

Tatars of Yalta may also be considered as the only remnants of the aborigines of the region. The arguments advanced by the author are presented clearly but in a very condensed form. No mention is made of the principles of the method involved and the evidence bearing on the conclusions is not as yet sufficient.



GENERAL ANTHROPOLOGY.

Edited by Franz Boas. With Contributions by Ruth Benedict, Franz Boas, Ruth Bunzel, Julius E. Lips, Robert H. Lowrie, James H. McGregor, N. C. Nelson, Gladys A. Reichard. D. C. Heath and Co., Boston. \$4.00. $8\frac{1}{2} \times 5\frac{3}{4}$; xi + 718; 1938.

The general trend in the writing of many anthropology texts has been that of developing a rather stereotyped discussion of ethnology, and then dropping the subject as though the entire field had been covered. The excellence of the present volume is the result of the thorough and careful coordination of ethnology with the other principle aspects of the subject; namely, paleontology, archaeology, linguistics, physical anthropology, and biology. Many chapters on the various subjects relative to general anthropology have been contributed by specialists in the particular fields, but even this fact would not have been such an important asset to the volume if it were not for the careful coordinating and editing of the materials by Dr. Boas.

The subject has been presented so graphically, and illustrated so aptly that the beginning student in anthropology should have no difficulty in gaining a firm background in the subject, even with a minimum of effort. The extensive list of bibliographic references accompanying each chapter makes the volume exceptionally valuable for the reference shelf.



LABOR IN THE UNITED STATES. *Basic Statistics for Social Security. A Report Prepared for the Committee on Social Security.*

By *W. S. Woytinsky. Social Science Research Council, 230 Park Ave., New York.* \$3.50. 9×6 ; xxii + 333; 1938.

In this country, the recent enactment of

laws relating to unemployment compensation and old age insurance has emphasized the need for still another type of classification of occupations—one that would give some precise information about the number of persons subject to these laws and the amount of money involved. The Committee on Social Security of the Social Science Research Council has, for this reason, undertaken to revise the 1930 census data on occupations so as to give an adequate foundation of facts to future discussions of the subject. The project was assigned to Dr. Woytinsky whose principal task has been to reassert the census data so as to arrive at a classification of employees according to industries rather than type of occupation and to achieve also the required segregation of employers and employees. The author has successfully and effectively carried out the project and in this volume presents his results. The first section of the book deals with the supply of labor, type of work, race, age, sex, and duration of employment. The second part discusses the demand for labor and regards the distribution, type and size of industrial establishments. Besides rearranging the census data the author also proceeds to estimate the conditions of the future. Of course, such extrapolation must be accepted with due caution but the conclusions reached are interesting. The methods employed in the redistribution of the data as well as the pertinent original figures are presented in sufficient detail and, although by this means the picture of employment is not substantially altered, the resulting classification deserves the attention of the students of the subject as well as of those charged with the forthcoming census.



ACCULTURATION. *The Study of Culture Contact.*

By Melville J. Herskovits. J. J. Augustin, New York. \$2.00. 9 x 6½; 155; 1938. This book deals with the methodology involved in the study of acculturation and stresses the necessity of historic controls and scientific objectivity in such studies. After defining the term acculturation and

stating the various and conflicting meanings that the word has been given, the author proceeds to discuss field methods employed in acculturation studies. Excerpts from studies on acculturated primitive peoples are quoted and evaluated in order to illustrate the practical method of approach to the analysis of the processes. In addition to full-length portraits of acculturated peoples, the affects of culture contacts on such restricted phases of cultures as religion, folklore, music, and linguistics are considered. The author also discusses available works of fiction dealing with problems of acculturation, and lastly, he gives some suggestions for future research on these problems, pointing out some areas in the world where particularly fruitful studies could be made, and dwelling briefly on the importance of studies on human personality from the point of view of the interplay between personality and culture.



LA PRÉHISTOIRE.

By A. Vayson de Pradenne. Armand Colin, Paris. 15 francs (paper); 17 francs 50 (cloth). 6½ x 4½; 224; 1938.

This excellent treatise on prehistory is concerned with the methods, materials, and sources of error in present-day studies of the eras of cultural development antedating all written records. M. Pradenne's definition of prehistory points to the fact that in spite of the advanced stages of civilization over the greater part of the world today, there exist contemporary prehistoric races. The methods for studying early civilizations are classified under the general heads of (1) geological, (2) archaeological, and (3) the study of human remains, and the manifestations of human activities.

The text contains detailed descriptions of the fundamental discoveries in the well-known stations of western Europe, Africa, Asia, the Pacific Islands, and America. Throughout the volume there is a note of warning that the method of handling materials and the interpretation of observations are just as important in discussing prehistory as the authenticity of the discoveries.

AN ARCHAEOLOGICAL SURVEY OF THE NORRIS BASIN IN EASTERN TENNESSEE. *Smithsonian Institution, Bureau of American Ethnology, Bulletin 118.*

By William S. Webb. Government Printing Office, Washington. \$1.00. 9½ x 5½; xv + 398 + 152 plates; 1938 (paper). An archeological survey of the areas to be inundated in the Tennessee Valley revealed 23 sites showing definite evidence of prehistoric occupation. On these sites were found 20 earth mounds, 9 stone mounds, 4 village sites and 7 caves. The remains of 50 wooden structures were uncovered, 20 of which were thought to have been dwellings and 34 of which have been designated as "town houses." A study of the skeletal remains shows the people to have been a little above medium height with brachycephalic or mesocephalic skulls, somewhat deformed because of the binding of the head in infancy. In only one site (No. 20) were the individuals distinctly dolichocephalic in character with heads long and narrow, high dome, and no artificial deformation. Thirty-nine charts, 152 plates, a list of references and an index complete the volume.



THE PEOPLES OF VIRGINIA.

By R. Bennett Bean. *Chapman and Grimes, Boston.* \$3.00. 8 x 5½; viii + 302 + 7 plates; 1938.

This work is essentially a supplement to the author's monographs on the anthropometric data he obtained by measuring Old Virginians. It is a compendium of the history of the ethnic development of Virginia from the date of its first settlement. In the first section of the book, Bean summarizes the history of the colonization of the state giving the names, national origin, and social position of many of the early settlers. In the second section there are listed for each county the names of the more important first families as well as the frequency distributions of the family names of the inhabitants according to national origin as observed in pre-revolutionary times and at present. The third and last part serves to give a very brief outline of the anthropometric

data he obtained. While the book will undoubtedly serve to elucidate further the author's findings on these peoples and will be useful for those interested, it cannot be said to be very exciting. It is far too condensed, having most of the time the characteristics of a telephone directory. Moreover, the author has omitted all discussions regarding the real pertinence of this work to the previous observations.



THE DOCTOR REMEMBERS.

By Sir James Crichton-Browne. *Gerald Duckworth and Co., London.* 7s. 6d. 7½ x 4½; 308; 1938.

The doctor's life was long—97 years!—and his interests wide. This is the last "bedside anthology" to come from his rich experience. If one likes anecdotes of famous people, they are here; if one likes anecdotes by a Scot about Scots, they are here. And if one is interested in another's thoughts on religion, politics, insanity, the function of the brain, education, and many other things, he will find them here. Even jokes and comic poetry are included.

As a picture of an eminent medical man of Victorian Britain, this book is fine. One can only wish that Sir James had given a little more space to his ideas about the mentally ill and their care (psychiatry was one of his special interests), but for them one may turn to his scientific papers. What was, perhaps, his basic concept, he states thus (p. 39): "Universities and lunatic asylums have this in common, that they are both concerned in promoting mental equilibrium."



MODERN MAYA HOUSES. *A Study of Their Archaeological Significance. Carnegie Institution of Washington Publication No. 502.*

By Robert Wauchop. *Carnegie Institution of Washington, D.C.* \$3.00 (paper); \$3.50 (cloth). 11½ x 9; vii + 181 + 37 plates; 1938.

Excavation of house mounds at the ruins of Uaxactun, Guatemala, (1932) made it

clear that very little information, except upon certain features of sub-structures, could be gleaned from excavation without some examination having first been made of modern houses and the way in which they fall to pieces. For this reason the ethnological work for the present study was done chiefly from an archaeological point of view, and is a comprehensive and detailed study of modern Indian house types in the Maya area, undertaken in 1934 with the purpose of collecting data to facilitate interpretation of ancient dwelling sites.

The text which minutely covers every portion of the house from the details of its foundation features to those of its thatched roof, is supplemented by numerous excellent drawings of the houses and the details of their structure. The work, with an index of place names only, has however a substantial list of references and contains an excellent group of some 150 photographs.



DIE ALAMANNEN VON ELGG. (Kt. Zürich.) *Eine anthropologische Untersuchung. Dissertation.*

By *Walster Trudel*. G. Büchi Buchdruckerei, Zürich. 5 Swiss francs. 9½ x 6½; 102 + 10 tables + 2 plates; 1938 (paper). In 1934, 142 graves—about half those on the site—dating from the seventh century A.D. were opened in Elgg, near Zürich. Of these 140 were in a condition usable for anthropological study. The author herein gives measurements and indices of the skulls, scapulae, clavicular, bones of the arms and legs, feet and vertebrae. Although his findings confirm the Nordic origin of the Alamanni, the Elgger group did not manifest a homogeneous type according to anthropological characteristics, especially in cranial indices. Dolicho-, meso-, and brachycephalic types were all found, with the former two predominating. Whether a mixture with foreign elements occurred during their wanderings to the south or only after their settlement among the Celts in Switzerland, the author was not able to conclude from his material. A bibliography and many tables are included.

THE SCIENCE OF SOCIETY. *An Introduction to Sociology.*

By *J. Rumney*. Gerald Duckworth and Co., London. 3s. 6d. 7¼ x 4¾; 125; 1938.

One cannot expect to fix a car without knowledge of the interrelation of its parts. Just so, the ills of our social system cannot be cured without recourse to a study of the delicate equilibrium that must exist among the institutions comprising it. Rumney's analogy indicates the practical service of sociology as a synoptic science. But in his view repair service is not enough. Sociology has a further obligation to foresee and control the course of social movements. Apropos of these considerations chapters are devoted to the structure of society, political and economic. The chapter on biological sociology concerns itself primarily with racial discrimination and concluding sections give briefly the history of sociology and methods used in its study.



BANTU BELIEFS AND MAGIC with *Particular Reference to the Kikuyu and Kamba Tribes of Kenya Colony; together with some Reflections on East Africa after the War.* Second Edition.

By *C. W. Hobley*. With an Introduction by *Sir James G. Frazer*. H. F. and G. Witherby Ltd., London. 15s. net. 8½ x 5½; 368 + [1]; 1938.

Since the first edition of this work appeared sixteen years ago, many changes have taken place in Africa, partly consequent upon new outlooks and policies inaugurated as a result of the World War. Most of the tribes have in recent years shown a remarkable adaptability and faculty for a degree of self government based on the British system. However, many problems still present a barrier to satisfactory adjustment between the old native social structure and increased European dominance. Hobley has attempted to analyze the principal religious, educational, economic, and governmental problems, and suggests means whereby stresses might be alleviated.

One who wishes to understand the difficulties involved should first have an in-

sight into the ancient native customs. The detailed and often tiresome enumeration of religious beliefs, magic, and laws should prove sufficient for the purpose.



PATAGONIAN YEAR.

By *Pedro Rubio*. Translated from the Norwegian by *Arthur G. Chater*. Methuen and Co., London. 7s. 6d. net. $7\frac{1}{2} \times 4\frac{1}{2}$; v + [2] + 208; 1938.

The author, a Norwegian land surveyor who for some time worked at his profession in Patagonia, narrates a few of the adventures he encountered while on a job there in 1916. As is well known, the country is bleak and uninviting but the author has perceived in the grasslands, dried salt lakes, and sandy deserts a certain beauty and charm which he succeeds in transmitting. The reader is apt at the end to feel a yearning to visit the place. All in all the book makes for interesting and amusing reading because at heart the author is a naturalist and human biologist. There are delightful pen portraits of the hearty Scots, the suave Argentineans and the shy natives with whom the author came in contact, and keen descriptions of the behavior of the animals, from horses to ostriches. It deserves to be read if only to learn something about a country which to many is just a geographic name.



LIFE AND LETTERS OF FIELDING H. GARRISON.

By *Solomon R. Kagan*. With an Introduction by *James J. Walsh*. Medico-Historical Press, Boston. \$3.00. $8\frac{3}{4} \times 5\frac{1}{2}$; xvi + 287; 1938.

An incredibly bad attempt at a biography of a great man. Garrison was a profound scholar, who also wrote with clarity, dignity, and charm. The heavy-footed bumbling and bungling of Kagan's *opus* seems somehow an offense to the fine and delicate spirit of its subject, who was as much an artist as a scientist. But quite apart from its literary shortcomings, the book gives no adequate picture of a full and rich life—a life that beautifully exem-

plified the fact that one may but rarely leave the serene quiet of the study and still not miss much of anything of real importance that the world has to offer.



OUR DAILY BREAD. *A Geography of Production.*

By *Sir Daniel Hall*. John Murray, London. 6s. net. $7\frac{1}{2} \times 5$; x + 169; 1938.

This simply written little book should fill a gap in the knowledge of many city dwellers, whether adults or children. Starting with breakfast and continuing through dinner and tea the author pounces one by one on the various edibles on the table and describes their origin and mode of production. The loaf of bread at breakfast leads to a discussion of wheat, its geographical distribution, harvesting tools, and the grinding of the grains into flour. In a similar manner the author takes up each dish as it comes along through the noon-day roast to the spices in the afternoon tea cakes. Maps and some excellent photographs illustrate the text. There is an index but no bibliography.



FOOD PLANNING FOR FOUR HUNDRED MILLIONS.

By *Radhakamal Mukerjee*. The Macmillan Co., New York and London. \$2.75. $8\frac{1}{2} \times 5\frac{1}{2}$; xviii + 267; 1938.

This authoritative review of the Indian economic situation, presents a survey of the trend of the food position in relation to population increase in India and an estimation of her total population capacity and food shortage, following the methods adopted in this connection by Pearl and Taylor for the United States.

The author, head of the Department of Economics and Sociology, Lucknow University, examines the relation between agriculture, nutrition and population in India and establishes certain food standards for the different regions. He pleads for a diminution of India's hordes of superfluous cattle, and discusses remedies of population pressure and the social

attitudes of the country toward marriage and family limitation.

Numerous tables, diagrams and a long and complete index supplement the text.



RAPPORT SUR LE PÈLERINAGE DU HEDJAZ de l'Année de l'Hégire 1356 (A.D. 1938).

Conseil Sanitaire Maritime et Quarantenaire d'Egypte, Alexandrie. Freec. 12½ x 9½; 123 + 5 tables; 1938 (paper).

This report embodies essentially the same features that were present in the preceding one (Q.R.B., Vol. 13, No. 2). From all accounts, it is evident that the sanitary precautions imposed upon the members of the pilgrimage have brought very satisfactory results in terms of general health both for the travellers and for the general populations of the lands traversed.

These reports are strongly indicative of the advances in public health and sanitation that can be accomplished when a little bit of honest effort and common sense on the part of the medical director is used.



NATURAL INCREASE AND MIGRATION: Greater Cleveland 1919-1937.

By Howard W. Green. Cleveland Health Council, 1001 Huron Road, Cleveland, Ohio.

\$1.00. 11 x 8½; 75; 1938 (paper).

The student of population and of migration will find this an exceedingly useful report. The results, presented in tabular and graphic form (10 maps, 26 charts, 16 tables) show the changes in composition and characteristics of the census tracts in Cuyahoga County, during a period of 19 years. Twenty-six brief paragraphs summarize the results—the net result of the study being that births exceed deaths by smaller and smaller margins, the rate of natural increase having “decreased from 17 in 1921 to around 3 during the period 1933 to 1937.”



RASSENKUNDE UND RASSEN GESCHICHTE DER MENSCHHEIT. Zweite umgearbeitete und erweiterte Auflage in zwei Bänden. Erster

Band. Die Forschung am Menschen. Vierte Lieferung (Bogen 23-31).

By Egon Freiherr von Eickstedt. Ferdinand Enke Verlag, Stuttgart. RM. 10.80.

10½ x 7; 353-496; 1938 (paper).

An idea of the extent of the additions made in this second edition (which will comprise two volumes instead of the original one) may be noted from the fact that page 361 of the present *Lieferung* 4 starts the section, dealing with the human form in general, contained in *Lieferung* 1 (beginning page 39) of the first edition noticed in these columns, Volume 8, Number 1. Many new illustrations have been added.



PROCEEDINGS OF CONFERENCE ON BETTER CARE FOR MOTHERS AND BABIES. Held in Washington, D. C., January 17-18, 1938. U. S. Department of Labor, Children's Bureau. Bureau Publication No. 246.

Government Printing Office, Washington. 20 cents. 9 x 6; ix + 171; 1938 (paper).

PROCEEDINGS OF THE CONFERENCE ON STATE CHILD-WELFARE SERVICES. Social Security Act, August 14, 1935, Title V, Part 3. Washington, D. C. April 4-6, 1938. U. S. Department of Labor, Children's Bureau. Maternal and Child-Welfare Bulletin No. 3.

Government Printing Office, Washington. 20 cents. 9½ x 5½; v + 155; 1938 (paper).

PATERNITY LAWS. Analysis and Tabular Summary of the State Laws Relating to Paternity and Support of Children Born out of Wedlock. In Effect January 1, 1938. U. S. Department of Labor, Children's Bureau, Chart No. 26.

Government Printing Office, Washington. 20 cents. 10½ x 7½; 83; 1938 (paper).



ZOOLOGY

IN SEARCH OF THE GYR-FALCON. An Account of a Trip to North-West Iceland. With a Memoir of the Author.

By Ernest Lewis. Constable and Co., London. 12s. 6d. 8½ x 5½; xxiii + 234 + [1] + 1 folding map; 1938.

The intrepid adventures of Ernest Lewis will command wide attention and admiration. From a very young boy, along with his keen interest in the birds of his English countryside, he was fired with a lasting ambition to see the gyr-falcon "the grandest of all winged things" in its native eyrie. This he accomplished with probably far greater success than he had dared to anticipate. In view of the untimely death of Mr. Lewis, at only twenty-nine, it is to be fervently hoped that he enjoyed to the fullest the satisfaction of having succeeded in his high venture.

Lewis spent two summer months of 1936 in north-west Iceland on this search. The crossing of the many fjords; the climbing "on the faces of sheer gorges" along narrow, rocky and snowy crags looking for the gyr-falcons' nests offered almost overwhelming difficulties. For him to surmount these hazards required particular ingenuity and courage, as he had suffered the loss of the his left arm and his right eye! But it can be truly said that he took each challenging experience in his stride—belittling every hardship. He went valiantly on and was rewarded by seeing these "matchless birds" in flight and in their eyries with the falcons brooding on the eggs guarded by the stalwart tiercels. Finally Lewis accomplished the almost impossible in taking six of the eyesses back to England in "feather perfect" condition! At the close of the book three of these young birds were still alive and being trained and flown by an expert in the ancient and romantic art of falconry.

The whole book is written most pleasingly in the fine, lucid, straightforward English prose for which the author had so great a talent and which is so conspicuous in his other books. The scientific value of the work is enhanced by photographs, descriptions of many varieties of birds seen, and also by a map of the territory covered in north-west Iceland. The memoir of the author, written by his father, is an illuminating and poignant chapter. It gives the reader further and more intimate insight into the character, rare courage, gallant spirit and unusual gifts of this versatile young nat-

uralist whose writings, in several fields, deserve unstinted praise.



TEXTBOOK OF ZOOLOGY.

By George Edwin Potter. C. V. Mosby Company, St. Louis. \$5.00. 8½ x 5½; 915; 1938.

TEXT-BOOK OF ZOOLOGY.

By W. F. Wheeler. William Heinemann Ltd., London. 10s. 6d. 8½ x 5½; xi + 256; 1938.

TEXTBOOK OF GENERAL ZOOLOGY. Third Edition.

By Winterton C. Curtis and Mary J. Guthrie. Wiley and Sons, New York and London. \$3.75. 9 x 5½; xvii + 682; 1938.

The classical collegiate excuse of eye-strain in explaining the lack of a thorough acquaintance with textbooks of zoology has lost its last leg, for Potter has given us an excellent text all done up on a new "eye-toned" paper. But the quality of the paper and the type of print are only two of the text's many admirable features. The author has hit upon something essentially new in pedagogy; a fact which is attested by the careful interweaving of the theoretical and practical phases of biology. The fundamental elements of zoology are presented in the usual manner of a detailed discussion of one or more organisms typical for a particular phylum. In addition to the sections on the classical phases of zoology, there are numerous chapters on such interesting subjects as animal behavior, distribution of animals, conservation, parasitism, genetics, and eugenics. The text is amply supplied with illustrative material, both graphic and photographic. A list of excellent references, a glossary, and a table of contents conclude the volume.

Little difference exists between the second of these texts and numerous other zoology books on the market yet certain features may cause it to be preferred by some educators. Physiological processes are woven into the discussion in connection with those forms best suited to a demonstration of the process at hand. Special chapters, however, deal more generally with the functions of the various organ

systems and in conjunction with them the fundamentals of biochemistry are presented. The final pages are devoted to histological methods for practical studies.

The last volume, a substantial text first appearing 12 years ago (cf. Q.R.B., Vol. 3, p. 140 and Vol. 9, p. 111) follows the same general lines as the two preceding editions, with such alterations, eliminations or additions as the authors deemed necessary.



- ✓ LA VIE DES MOUCHES ET DES MOUSTIQUES.
By E. Séguy. Librairie Delagrave, Paris.
16 francs (paper); 20 francs (cloth).
7½ x 4½; 254; 1938 (paper).

MOSQUITOES OF THE ETHIOPIAN REGION.
II.—*Anophelini. Adults and Early Stages.*
By Alwen M. Evans. British Museum
(Natural History), London. 20s. 10 x 7;
x + 404; 1938.

As complete a résumé as could be given for such a large order as the Diptera is found in the first of these volumes. Séguy presents the material in two sections: the first on flies, and the second on mosquitoes. Each section describes the various egg-laying activities of the females and the life histories of the larvae and adults of the most representative species of the order. The different forms of myiasis caused by the flesh, bot, and warble flies, the rôle of *Glossina* in trypanosome infections, and of course, the part played by mosquitoes as malaria and yellow fever vectors, are all recounted. Apparently the author still believes that warble flies (*Hypoderma*) that attack cattle are taken into the mouth when the animal licks itself. Actually the larvae penetrate the skin at the site where the eggs are laid (chiefly on the hind legs) and migrate to the region of the animal's gullet. However, the general reader will find this book pleasant and instructive reading. There are several illustrations.

The work on the *Anophelini* of Ethiopia completed after the author's death in 1937, gives an account of the species for that region so far as they are known. Keys to all the stages of their life history are included for ready identification of this important tribe of malaria vectors.

This monograph is one in every sense of the word; every species is minutely described in all stages, and whatever is known of their habits, distribution, and relation to malaria is included. Practically every page has an illustration.



THE CALIFORNIA WOODPECKER AND I.
A Study in Comparative Zoology in which are set forth numerous facts and reflections by one of us about both of us.

By William E. Ritter. University of California Press, Berkeley. \$3.50. 9½ x 6; xiii + 340.

Dr. Ritter's addicts have come to expect much of him, and this book will not disappoint them. But it will surprise them. The woodpeckers are highly specialized birds, and their Pacific Coast representative is a highly specialized woodpecker. It has abandoned the insectivorous habits of its eastern relatives and subsists almost entirely on nuts which it stores away against the lean days of winter, for it has ceased to be migratory. Its favorite storage place is the bark of oak and pine trees. Dr. Ritter calculated that one tree which he observed had been drilled over 30,000 times by these birds, and estimated that another had nearly twice as many holes in its bark.

The woodpecker's social system is exclusively communistic—about a half dozen birds will cooperate in excavating a community nest, to which all the females will contribute indiscriminately after promiscuous mating. All the birds will then share the incubation, working in shifts, and when the eggs have hatched all the parents will feed all the young.

The subtitle of this book (which does not appear on the cover) shows that it is much more than a mere description of the social, economic, and biological activities of these birds. Dr. Ritter's reflections on what men and woodpeckers have in common and in what respects they differ gives his book great philosophical significance, and renders it thought-provoking. The book is adequately indexed and documented, attractively printed and substantially bound.

J ANIMALS WITHOUT BACKBONES. An Introduction to the Invertebrates.

By Ralph Buchsbaum. University of Chicago Press, Chicago. \$3.75. 9 x 6½; ix + 371 + 128 plates; 1938.

This is certainly one of the most fascinating treatments of invertebrate zoology that has appeared on the market. The author prefaces the book with the remark that

Elementary and general accounts of the invertebrates, suitable for the beginning college student or layman, have been limited to two sorts of books: natural histories, which describe the habits of a great many animals but are lacking in descriptions of basic structure and in theory, and formal textbooks, which are packed with morphological detail and technical terminology. This book is an attempt to present the main groups of invertebrate animals in simple non-technical language. Each group is used to illustrate some principle of biology or some level in the evolution of animals from simple to complex forms.

College students are certainly fortunate these days when they may study from textbooks that read like novels. But aside from the text, it is the illustrations that catch this reviewer's fancy. The bold semi-diagrammatic pen-and-ink drawings are executed in such a manner that even the most complex morphological details of construction are extremely lucid. The photographs are also excellent.



CONTRIBUTIONS TO SPECIAL SCIENTIFIC MEETINGS, 1938. Part I. Rate of Growth. Conseil Permanent International pour l'Exploration de la Mer. Rapports et Procès-Verbaux des Réunions, Volume 108.

Conseil Permanent International pour l'Exploration de la Mer. Andr. Fred. Høst et Fils, Copenhagen. Kr. 5.00. 10½ x 8½; xv + 114; 1938 (paper).

REPORT OF SPECIAL SCIENTIFIC MEETINGS, 1938. Part II. Light Measurements. Part III. Salmon Migrations. Conseil Permanent International pour l'Exploration de la Mer. Rapports et Procès-Verbaux des Réunions, Volume 108.

Ibid. Part II, Kr. 1.00; Part III, Kr. 1.50. 10½ x 8½; Part II, 21; Part III, 35; 1938 (paper). Price for the three parts, Kr. 7.50.

Part I contains sixteen papers on the

growth of fish, mostly from the Baltic and North Seas. The contributors include Johan Hjort, Per Ottestad (2 papers), Einar Lea, Oscar Sund, Gunnar Rollefson (2 papers), L. Fage and A. Veillet, Erik M. Poulsen (2 papers), Michael Graham, K. A. Andersson (2 papers), A. Bückmann, Arvid R. Molander, and Aage J. C. Jensen (2 papers).

Part II includes four papers: The effect of surface conditions on the intensity and angular distribution of submarine daylight, by H. H. Poole; Measurements on the angular distribution of submarine light, by Hans Pettersson; Trial methods of measuring transparency of sea water, by Michael Graham; and a paper in German on carbonic acid assimilation and quality of light in marine plankton diatoms, by E. K. Gabrielsen and E. Steemann Nielsen.

The two papers comprising Part III are: A review of recent salmon marking experiments in Norway, by Knut Dahl; and Some preliminary observations on the migrations of salmon (*Salmon salar*) on the coasts of Scotland, by W. J. M. Menzies.



FAUNA OF THE CAVES OF YUCATAN. Carnegie Institution of Washington Publication No. 491.

By A. S. Pearse, with the Collaboration of Nathan Banks, Joseph C. Bequaert, Joseph C. Chamberlin, Ralph V. Chamberlin, B. G. Chitwood, William J. Clench; Edwin P. Creaser, Norma C. Furtos, Helen T. Gaige, Theodore H. Hubbell, Carl L. Hubbs, Libbie H. Hyman, Wilton Ivie, Remington Kellogg, Harlow B. Mills, J. Percy Moore, C. F. W. Muesebeck et al., Grace F. Pickford, Horace W. Stunkard, George W. Wharton, William Morton Wheeler, Charles Branch Wilson, and Frederick A. Wolf. Carnegie Institution of Washington, D. C. \$3.00 (paper); \$3.50 (cloth). 11½ x 9; iii + 304 + 8 plates; 1938.

During the summer of 1936 the senior writer visited 27 caves distributed throughout the State of Yucatan. The faunal collections were subsequently sent to various authorities for identification and their findings are included in this

report on the cave-dwelling animals of that peninsula. The list includes flatworms, annelids, arthropods, and vertebrates (also the fungal flora). Many species are new to science, indicating that this type of ecological niche deserves further investigation not only to help clear up phylogenetic obscurities of taxonomic interest, but also to help understand the evolutionary processes by which these animals became adapted to their troglodytic life. The writer has included an introduction on the subject of caves and their fauna with especial reference to those of Yucatan.



PROBLEMS OF ANIMAL ECOLOGY.

By F. S. Bodenheimer. *Oxford University Press, London.* 12s. 6d. 8 $\frac{1}{2}$ x 5 $\frac{3}{8}$; vi + [2] + 183; 1938.

Every science apparently undergoes similar stages of development. The science of ecology as a separate discipline is no exception for as research in that field is being further pursued it becomes evident that "things aren't as simple as they seem." Original interpretations of fundamental "laws" have to be revised, different experimental techniques and approaches have to be devised and with the new data acquired only gradually are the real truths revealed.

The author of this volume points out that problems in animal ecology have to be attacked not only from a qualitative viewpoint, but also from a quantitative or statistical angle. Most biologists, as the author states, are mathematicophobic, and it will undoubtedly take a long time before mathematical analysis will assume its proper place in biology, but its need in the field of ecology is expressed by the author. Habitat concepts, populations, biological equilibria, and the interaction of environment and heredity within the organism are some of the problems discussed.



ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Volume XXIII, Part 3, Numbers 10-16.*

New York Zoological Society. *Zoological*

Park, New York. \$1.50. 10 $\frac{1}{2}$ x 7; 219-318 + 16 plates; 1938 (paper).

This part contains the following papers: Morphology of the hypophysis of the common goldfish (*Carassius auratus* L.), by W. Randall Bell; Pathology of *Dirofilaria immitis*, by Joel Hartley; Papilloma of the skin occurring in an electric eel, *Electrophorus electricus* (Linnaeus), by C. W. Coates; Arithmetical definition of the species, subspecies and race concept, with a proposal for a modified nomenclature, by Isaac Ginsburg; Eastern Pacific expeditions of the New York Zoological Society. XIV. Introduction, itinerary, list of stations, nets and dredges of the Eastern Pacific Zaca Expedition, 1937-1938, by William Beebe. XV. Seven new marine fishes from Lower California, by William Beebe and John Tee-Van; and Deep-sea fishes of the Bermuda oceanographic expeditions. Family Anguillidae, by A. Vedel Taning.



LIFE HISTORIES OF NORTH AMERICAN BIRDS OF PREY. (Part 2). *Orders Falconiformes and Strigiformes. Smithsonian Institution, United States National Museum, Bulletin 170.*

By Arthur C. Bent. *Government Printing Office, Washington.* 60 cents. 9 $\frac{1}{2}$ x 5 $\frac{3}{8}$; viii + 482 + 92 plates; 1938 (paper).

This volume is Part 2 of the complete work on the life histories of the North American birds of prey (Part 1 reviewed in Vol. 13, No. 1) and deals exclusively with the orders Falconiformes and Strigiformes. As in the earlier work, Bent has discussed the different species under the headings of (1) habits, which include nesting, number and color of eggs, plumage changes, food and general behavior; and (2) distribution, which incorporates general, breeding and winter ranges, and migration habits. Some 20 species of Falconiformes and some 55 species of Strigiformes have been classified according to the nomenclature of the 1931 Check-List of the A. O. U. The volume contains 92 well chosen photographs of nesting sites, nests, eggs, young, and changes in plumage of a number of species, a bibliographic list of some 520 titles and an index.

AN INVESTIGATION OF THE EFFECTS OF MILK WASTES ON THE BRISTOL AVON. *Fisbery Investigations, Series I, Volume 4, Number 1.*

By F. K. T. Pentelov, R. W. Butcher and J. Grindley. H. M. Stationery Office, London. 4s. 6d. (Obtainable in North America from British Library of Information, New York). \$1.35. 10 $\frac{1}{2}$ x 7; 80 + 3 plates; 1938 (paper).

A detailed study on the effect of pollution from a milk factory and the recovery of the river afterwards. The most obvious effect was the large growth of sewage fungus. Algae growth also showed a condition of serious pollution. Just below the milk factory the river was practically barren of fauna but where the mixing of the effluent with the river water was complete leeches, molluscs and tubificids were found. Many charts, tables and figures exhibit the findings. In an appendix will be found an account of 'Methods of chemical examination used in the survey,' and plant and fauna lists.



FIELD BOOK OF FRESH-WATER FISHES OF NORTH AMERICA NORTH OF MEXICO.

By Ray Schrenkeisen. Edited by J. T. Nichols and F. R. LaMonte. G. P. Putnam's Sons, New York. \$3.50. 6 $\frac{1}{2}$ x 4; xii + 312; 1938.

Here is an excellent comprehensive guide which fulfills a long-felt need. Its author, late associate editor of *Field and Stream*, was well equipped to bring together all the necessary material from widely-scattered sources—monographs, articles in journals and magazines, textbooks, etc. The final work on the manuscript has been ably done by the associate editors. The line drawings throughout the text help to clarify the descriptions and a glossary and extensive index complete what we (although not being fishermen) venture to believe will long be a classic.



MEDICAL ENTOMOLOGY. *A Survey of Insects and Allied Forms which Affect the Health of Man and Animals. Second Edition.*

By William A. Riley and Oskar A. Johannsen. McGraw-Hill Book Company, New

York and London. \$4.50. 9 x 6; xiii + 483; 1938.

Minor changes and additions have been made throughout this text due to developing knowledge concerning such topics as the black widow spider, the value of maggots in the treatment of osteomyelitis and similar infections, the theory of the transmission of kala-agar by *Phlebotomus*, that equine encephalomyelitis is mosquito-borne, changing viewpoints regarding the distribution and the vectors of Rocky Mountain spotted fever, endemic typhus, Chagas' disease, etc.



DIE WILDLIBENDEN SÄUGETIERE MITTELEUROPA.

By Wilhelm Bieger and A. Wahlström. Carl Winter's Universitätsbuchhandlung, Heidelberg. RM. 5. 6 $\frac{1}{2}$ x 4 $\frac{1}{2}$; ix + [1] + 88; 1938).

This little pocket guide to the wild mammals of Central Europe contains first of all a discussion of wild animals in general, their various manners of life, development of senses, reproduction, distribution, duration of life, numbers, etc. Following this general part there are presented descriptions (with illustrations) of the tracks of the several animals, a glossary of German huntsmen's terms, descriptive text and illustrations for each of the animals. Indices of German and scientific names of the mammals are appended.



ANIMAL LIFE IN FRESH WATER. *A Guide to British Fresh-Water Invertebrates.*

By Helen Mellanby. Foreword by L. E. S. Eastham. Methuen and Co., London. 8s. 6d. net. 7 $\frac{1}{2}$ x 4 $\frac{1}{2}$; viii + 296; 1938.

This is a guide to use either as a text for schools, where fresh-water life in captivity provides one of the easiest forms of nature study, for the university graduate who has had little contact with field work, and for the amateur naturalist. The pleasing style of the text (one quite forgets that this is a *guide*), the excellent line drawings and the useful index fulfill the purpose of the author.

THE INSECTS OF NORTH CAROLINA.

By C. S. Brimley. *North Carolina Department of Agriculture, Division of Entomology, Raleigh, N. C.* \$2.00. 9 x 6; 560; 1938.

While state check-lists of birds, mammals, and reptiles are fairly abundant, only rarely does one appear devoted to insects. Naturally such an annotation cannot be considered complete, but more than 10,000 species of insects and near insects are listed as having been found or reported from the state. Perhaps this fine list will provide an impetus for similar work in other states.

FIELD GUIDE TO NEW ENGLAND TURTLES.
New England Museum of Natural History. Natural History Guides, No. 2.

By Harold L. Babcock. *New England Museum of Natural History, 234 Berkeley St., Boston, Mass.* \$1.00. 7½ x 5; 56; 1938 (paper).

This little booklet is admirably made up and will serve as a valuable adjunct to the nature lover's library of field guides. Each of the eighteen species of turtles listed from New England is described together with something of its life history. Each turtle is also beautifully pictured in color.

AN INTRODUCTION TO THE VERTEBRATES.
Second Edition.

By Leverett A. Adams. *John Wiley and Sons, New York.* \$3.50. 9 x 5½; vii + 479; 1938.

The section on comparative anatomy has been practically rewritten and is now placed following the first section thus transposing the original second section (dealing with mammals as groups) to the back of the book, where it can be studied or not, as desired.

ECOLOGICAL DISTRIBUTION OF THE MAMMALS IN THE CRANBROOK AREA. *Cranbrook Institute of Science, Bulletin No. 13, August, 1938.*

By Harold J. Leraas. *Cranbrook Institute of Science, Bloomfield Hills, Michigan.* 15 cents. 9 x 6; 20 + 2 plates; 1938 (paper).

Because the plants of an area have a direct influence upon its mammal population, a survey of the distribution of the mammal fauna for a small area in Oakland County, Michigan, is given in this brief bulletin.



THE UNIVERSITY OF COLORADO STUDIES, *Volume 25, Number 4, 1938.* Containing the Following Articles: *A Criterion for Admission to Collegiate Work*, by George H. Light; *Notes on Colorado Operculate Discomycetes*, by Paul F. Shope; *Catalogue of Greek and Roman Coins at the University of Colorado*, by William and Mary Wallace; *Type Specimens of Fossils in the University of Colorado Museum*, by Hugo G. Rodeck.

University of Colorado, Boulder. \$1.00. 10 x 6½; 86; 1938 (paper)



BOTANY

THE WORLD WAS MY GARDEN. *Travels of a Plant Explorer.*

By David Fairchild assisted by Elizabeth and Alfred Kay. *Charles Scribner's Sons, New York and London.* \$3.75. 9½ x 6½; xiv + 494 + 128 plates; 1938.

Here is a highly significant biography, as well as an illuminating record of a botanist who is a world traveller and a pioneer in agricultural exploration. David Fairchild came from the finest of intellectual stock, and his earliest years were spent in the forest clearing which was the campus of the Michigan State College of Agriculture, the first institution of its kind in the United States. Later he attended the University of Kansas, where his father was called to the presidency in 1879.

To enumerate the men who influenced Fairchild in his choice of a profession, would be to give a roster of this country's early botanists, and the pioneers in the study of the diseases of plants. Fairchild's classmates carried their learning, and their enthusiasm over agricultural problems, into all the corners of the globe

and he frequently visited them in his years of extensive travel in search of plants and foods for introduction into the United States. The account of these friendships with many scientists, and the recollections of their individual contributions to the botanic and economic development of the United States during the last sixty years, weaves a brilliant and delightful pattern of reminiscence all through the book.

The number of plants, fruits, and vegetables introduced from Europe, Asia and Africa by Fairchild and his co-workers, and successfully established under suitable climatic conditions in different parts of this country, is truly astonishing. They are so varied that they seem to include almost all of the items on a present day American menu for either man or beast!

All readers and students of this profoundly worth-while and delightful book will feel a lasting gratitude to Elizabeth and Alfred Kay for having finally succeeded in persuading Fairchild to write of his life's work, and his unique opportunities in exploring the gardens of the world. The two hundred photographs used in illustrating the book were taken by the author, and form a remarkably vivid record of his travels. The nine-page index is indicative of the careful preparation of the text.



THE AMERICAN PLANT MIGRATION. *Part I. The Potato. Anthropological Series, Field Museum of Natural History, Volume 28, Number 1, July 28, 1938. Publication 418.*

By Berthold Laufer. Prepared for Publication by C. Martin Wilbur. *Field Museum of Natural History, Chicago. \$1.50. 9½ x 6; 132; 1938 (paper).*

This treatise on the potato, by the late Berthold Laufer of the Field Museum, is far more entertaining than anyone would expect from only the daily acquaintance from childhood that one has with this article of food. All of the varieties of the potato—and there are now about a thousand of them not including the sweet potato which is quite another plant—derive from one single species, *Solanum*

tuberosum. It is known that the home of this species is in the Andes of South and Central America although it has never yet been found in the wild state. The great adaptability of the potato to climate, elevation and soil has made what was once a despised article of food, when introduced into older civilizations, now an article of staple diet. That it is a plant of great antiquity is known by the dried remains found in Inca graves and by ancient Peruvian vessels and whistles made in the shape of the potato. From the seed there is chance of procuring a new variety but the eyes of the tuber seldom produce other than the kind planted. The author traces the migration of the potato (together with its changing characteristics) into all countries of the world, and the progress of its rise to an important place in the diet of many peoples. He includes an appendix on nomenclature and on world statistics of the potato, a bibliography, and an index.



ALICE IN VIRUSLAND.

By Paul F. Clark. *Society of American Bacteriologists, University of Wisconsin, Madison, Wis. \$1.00. 10 x 7; 23; 1938.*

A trip down almost any "rabbit hole" is exciting, but bacteriology's Alice has the doubly interesting experience of being given a "germ's eye" view of human beings, and of hearing a chat between Theobald Smith and Antony van Leeuwenhoek. Overhearing this conversation is just one of the things that happens to Alice in that strange land at the bottom of the ventilator shaft where Ferdinand and the monkey leads her. In not the least of her adventures she must answer charges of man's

Brutality and blind-spots.
Power to the panders and paranoiacs.
Blind selfishness and blundering sentimentality!

But Alice escapes conviction and is sent by the Microbe Parliament across the river Styx to "... consult the shades of some of the humans that have had sense enough to study us. They must surely

be the wisest." Here, as she meets Pavlov, a bell rings, and he invites her to tea. Though she enjoys her bread and butter and jam, she doesn't "quite understand" the ideas Erasmus and the Unknown Soldier exchange, and is glad to chase Ferdinand again.

In such a gay, gentle way, Professor Clark exposes a few weaknesses of the human species, ending his brief paper with an epilogue, taken from Epictetus: "He who remembers what man is, can be discontented at nothing which happens."

No review of this book would be complete without a reference to its amusing rhymes and illustrations. All bacteriologists should read at least the description of a virus, and the Spirochaete Chant, noting meanwhile that the book is the presidential address delivered before the Society of American Bacteriologists at its 40th annual meeting last year.



AN INTRODUCTION TO BOTANY.

By Arthur W. Haupt. McGraw-Hill Book Co., New York and London. \$3.00. 9 x 6; xii + 396; 1938.

A TEXTBOOK OF GENERAL BOTANY for Colleges and Universities. Fourth Edition.

By Richard M. Holman and Wilfred W. Robbins. John Wiley and Sons, New York; Chapman and Hall, Ltd., London. \$4.00. 9 x 5½; xvii + 664; 1938.

The first book listed is a clear, concise, and comprehensive study of botany including in its scope all the fundamental concepts common to both animal and plant life. The gross aspect of the vegetative organs is described previous to the study of minute structural details, so that the student is given a complete picture of the general functions of the plant body as a whole. The book, intended for use in a general biology course, has many helpful drawings and photographs.

The same plan in the organization and treatment of the subject matter has been adhered to in the revision of the second of these texts that the senior author, the late Professor Holman, had outlined for the earlier editions, but recent researches have required considerable revision and additions, particularly in certain fields

such as the absorption and conduction by roots, rise of sap in stems, conduction of foods, hormones and the classification of tissues. A glossary, which includes the origin of words as well as the definition of terms, has been added.



LEAF XANTHOPHYLLS. Carnegie Institution of Washington Publication No. 490.

By Harold H. Strain. With a Foreword by H. A. Spoehr. Carnegie Institution of Washington, D. C. \$2.00 (paper); \$3.00 (cloth). 10 x 6½; xi + 147; 1938 (paper).

It is possible to list only a few of the findings of this work.

"The xanthophylls from the leaves of a number of different species of plants are mixtures of twelve or more pigments. These xanthophylls are mono-, di-, tri-, and tetra-oxy derivatives of carotenes. The principal constituent of the mixture is lutein. . . . The only satisfactory method for the separation of all the leaf xanthophylls from one another is chromatographic adsorption. . . . [They] are so similar that it has not been possible to devise quantitative methods for their separation. . . . The crystalline leaf xanthophyll isolated by present methods is usually contaminated with colorless substances. . . . A study of the properties of the pure xanthophylls and of mixtures of these has demonstrated that a pure pigment can be identified as such only by the determination of a number of its physical and chemical properties."

Graphs, tables and figures are given in the text and the work concludes with a bibliography of 190 titles, and an author and a subject index.



SAGAS OF THE EVERGREENS. The Story and the Economic, Social and Cultural Contribution of the Evergreen Trees and Forests of the World.

By Frank H. Lamb. W. W. Norton and Company, Inc., New York. \$3.50. 8½ x 5½; xi + 364; 1938.

This is in no way a scientific treatise although the author has a wide acquaintance with trees in the technical sense. "The pages are but the absorption of forty years of association with trees and men of the trees, and many thoughts and ideas are what I have gained from them." Mr. Lamb has seen every forest area and

every forest industry in the United States from Alaska to Panama and has visited all of the great forests of the world. His book makes available to tree lovers a wide range of accurate and odd bits of information concerning the history and cultivation and uses of the evergreen, beginning, of course, with the Ginkgo. The volume is abundantly illustrated and contains a selected bibliography and a carefully prepared index.



AN INTRODUCTION TO INDUSTRIAL MYCOLOGY.

By George Smith. Foreword by Harold Raistrick. Edward Arnold and Co., London; Longmans, Green and Co., New York. \$5.20. 8½ x 5½; xii + 302; 1938.

This book is intended to assist those who are commencing the study of "moulds" rather than of fungi in general. . . . There has been up to the present no book in English, apart from highly specialized monographs, dealing particularly with the fungi which are of importance in industry.

Sufficient general mycology is included to enable the student to follow up the subject in the standard text-books. The major portion of the book, however, consists of descriptions and illustrations of most of the genera of moulds which are of regular occurrence in industrial products, with more detailed consideration of the genera which are of greatest importance.

The volume contains many excellent illustrations, literature lists complete each section, the final chapter gives a list of mycological journals, standard texts, etc., and there is a useful index.



PHYTOGEOGRAPHICAL PROBLEMS OF EASTERN CANADA. *Contributions du Laboratoire de Botanique de l'Université de Montréal.* No. 30.

By Frère Marie-Victorin. *Institut Botanique, Université de Montréal, Montréal.* 50 cents. 9 x 6; 70; 1938 (paper).

A study of the flora of eastern Canada gives fresh evidence concerning the great age of some of the forms, as well as the more recent formation of species and varieties. A comparison of their features, and mapping of their ranges show that

there are endemic species, that is, species with a limited and consistent distribution. Also it becomes evident that there are epibiotic species, that is, survivors of extinct floras or associations, persisting as relics far away from their main present ranges. The distribution of many plant forms, the effect (on distribution) of the glacial and interglacial periods, soil chemistry, the nuntak theory also are among the topics discussed. Many charts, maps and figures add to the interest of the text.



EXPERIMENTS IN PLANT LIFE.

By William J. Claxton. Wells Gardner, Darton and Co., London. 3s. 6d. net. 7½ x 4½; xiv + 104; 1938.

For the wide-awake boy or girl who is interested in individual experimentation, especially in the field of botanical wonders, this little volume should be a valuable guide. The substance of the book is centered around 30 experiments intended to lead to an elementary knowledge of the soil and of the physiology and economy of a number of our common species of plants.

The book is cleverly illustrated, and is written in such a manner as to be thoroughly understood by a child of early high school age. It may prove itself worth while even to those oldsters of us who were not fortunate enough to be able to dabble in the mysteries of the plant world either in high school or college.



THE STRUCTURE OF ECONOMIC PLANTS.

By Herman E. Hayward. *The Macmillan Co., New York.* \$4.90. 9½ x 6½; x + 674; 1938.

A useful book, especially in the teaching of applied botany. The first part of the volume deals with the point of view of developmental anatomy together with the nomenclature used in Part II. In Part II the author has brought together, from widely scattered sources, material dealing with the structure and developmental anatomy of certain economic plants. Altogether sixteen plants are discussed

in as many chapters and are as follows (we omit the technical names): corn, wheat, onion, hemp, beet, radish, alfalfa, pea, flax, cotton, celery, sweet potato, white potato, tomato, squash, lettuce. The chapters conclude with literature citations. There are 340 text figures, and an adequate index.



PLANT FORM AND FUNCTION.

By F. E. Fritsch and E. J. Salisbury. G. Bell and Sons, Ltd., London. 17s. 6d. $8\frac{3}{8} \times 5\frac{1}{4}$; viii + 668; 1938.

The preparation of this book—a combination of the authors' two previous works, *An Introduction to the Study of Plants* and *An Introduction of the Structure and Reproduction of Plants*—has involved many changes and additions in the text material and an increase in the number of illustrations so that it is practically a new work. In scope, it more than covers the first year university syllabus and aims to provide an adequate foundation for a non-specialized graduate course. The volume is abundantly illustrated and well documented and contains an extremely useful index.



PLANT GROWTH-SUBSTANCES, *Their Chemistry and Applications, with Special Reference to Synthetics.*

By Hugh Nicol. Chemical Publishing Co., New York. \$2.00. $7\frac{1}{8} \times 5$; xii + 108; 1938.

Two chapters for the layman introduce the subject of this book which is written by the assistant bacteriologist of the experimental station at Rothamsted. The succeeding chapters are necessarily technical but not impossible of mastery by the intelligent reader interested in the chemistry of growth-controlling substances. Information is given which will be of use to gardeners, horticulturists, botanists, biochemists and pathologists. The various chapters are well documented and the book contains a number of illustrations and an authors' index.

FERNS OF THE SOUTHEASTERN STATES. *Descriptions of the fern-plants growing naturally in the States south of the Virginia-Kentucky State line and east of the Mississippi River.*

By John K. Small. Drawings by Ruth S. George. Science Press, Lancaster, Pa. \$3.50. $8\frac{1}{2} \times 6$; 517; 1938.

This manual has been prepared for the tourist as well as for the student. Of the 196 species listed and figured about 30 have never before been described. It was the belief of the late Dr. Small that "it is probable that fern discoveries of importance can still be made in the southeastern states." In addition to being an excellent guide, well illustrated, with glossary and index, the volume contains an interesting section on the cultivation of ferns.



WILD FLOWERS OF OHIO.

By Harold L. Madison. The Cleveland Museum of Natural History, Cleveland, Ohio. \$1.50. $6\frac{1}{2} \times 3\frac{1}{2}$; 190; 1938.

In this condensed pocket guide all unnecessary material has been eliminated. Opposite each left-hand page, on which are briefly described from eight to thirteen plants, are line drawings (usually excellent although small, ca. $1" \times 1\frac{3}{8}"$) showing the necessary features of the plants listed. We give a sample of the text: "676. Round-leaved Mint. *Mentha rotundifolia*. Lavendar. Spikes 2-4 in. long in fr. Plant hairy, lvs. wrinkled and not veined below. July-Sept. Waste places." A detailed index and glossary are included.



ALGAE: *The Grass of Many Waters.*

By Lewis H. Tiffany. Charles C Thomas, Springfield, Illinois. \$3.50. $9 \times 5\frac{1}{2}$; xiii + 171; 1938.

The author states in the preface that his book is not written for those who already know about algae. For those who do not, whether amateur naturalist or student, this will be found an entertaining treatise—written largely from an ecological point of view but devoid of formidable technical language, generously

illustrated, and containing a list of references and an index. It provides a reason for the vacationer, who plans to dwell near a body of water, to include a microscope in his equipment.



THE DISTRIBUTION OF IMPORTANT FOREST TREES OF THE UNITED STATES. *United States Department of Agriculture Miscellaneous Publication No. 287.*

By E. N. Munn. *Government Printing Office, Washington, D. C.* 35 cents. 11 $\frac{3}{8}$ x 9; 175; 1938 (paper).

One hundred and seventy maps show the distribution of as many species and varieties of forest trees. This survey has been many years in the making and is still incomplete. One of the objectives "of the present publication . . . is to stimulate interest in the accumulation of more accurate information on the distribution of our North American trees." A useful source book for the forester and lumberman, the naturalist and botanist, as well as the manufacturer.



COMMON BRITISH GRASSES AND LEGUMES.

By J. O. Thomas and L. J. Davies. *Longmans, Green and Co., New York and London.* \$2.20. 8 $\frac{1}{2}$ x 5 $\frac{3}{8}$; vii + 124; 1938.

"This book contains a general description of the common grasses and legumes with which the British farmer is concerned. It is intended as a guide to the identification of the various species in the field, and has been written to meet the needs of farmers, schools, young farmers' classes and Agricultural Colleges." The volume is generously illustrated, has a reference list of 22 titles, a glossary and an index.



TREES AND MEN.

By Eleanor Hughes-Gibb. *Alexander Moring, London.* 8s. 6d. net. 9 $\frac{1}{2}$ x 7 $\frac{1}{2}$; viii + 170 + [1]; 1938.

Waxing poetic and religious in turn, the author writes lengthily about God and man and trees in general, and more specifically about the products of trees,

afforestation in various countries, parasites, forest fires, etc. The volume is illustrated by photographs and some rather nice drawings by Archdeacon Lonsdale Ragg. There is an adequate index but no bibliography.



THE PHYSIOLOGY OF PLANTS.

By William Seifriz. *John Wiley and Sons, New York; Chapman and Hall, London.* \$3.50. 9 x 5 $\frac{1}{2}$; vii + 315; 1938.

This volume has been written for the student who has a background in general botany, physics and chemistry. It is well documented, illustrated, and indexed and should be useful to teachers of plant physiology.



BACTERIOLOGY *For Students in General and Household Science. Fourth Edition.*

By Estelle D. Buchanan and Robert E. Buchanan. *Macmillan Company, New York.* \$3.50. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xv + 548; 1938.

In the revision of this text the keys to families and genera in the chapters on classification of bacteria, yeast and molds have been expanded and placed in the appendices. A chapter on the characters of viruses and bacteriophages has been added.



MORPHOLOGY

CONTRIBUTIONS TO EMBRYOLOGY. *Volume XXVII, Nos. 160 to 169. Carnegie Institution of Washington Publication No. 496.*

Carnegie Institution of Washington, D. C. \$4.50 (paper); \$5.50 (cloth). 11 $\frac{1}{2}$ x 9; 305 + 44 plates; 1938.

The following papers appear: On the placentation of the Macaque (*Macaca mulatta*), from the time of implantation until the formation of the definitive placenta, by George B. Wislocki and George L. Streeter (13 plates, 1 text-figure). The investigators divide the early period of placental development in the macaque into three stages (up to the 35th day, when the placenta has eventually attained its final character). These stages, begin-

ning with the 9th day are described and comparisons are made with those of man, of platyrrhine monkeys and of tarsius.

The Yale embryo, by Elizabeth M. Ramsey (3 plates, 1 text-figure). This study of an embryo 13-14 days old lends support to opinions concerning the early development of the human embryo "long current but admittedly based upon too little evidence for acceptance as established facts."

A human embryo in the bilaminar blastodisc stage (the Edwards-Jones-Brewer ovum), by John I. Brewer (9 plates). This embryo, obtained by hysterectomy, was fixed immediately after removal so that there was no post-mortem change or distortion. A very clear picture of the condition of a normal, 15-day-old human embryo.

Young human ovum detected in uterine scraping, by Elemér Scipiades, Jr. (1 plate). The age of this embryo (probably somewhat distorted, due to the scraping and faulty fixation technique) is placed at 11 to 12 days.

Some observations on the vascular system of a female fetal finback, by Robert Walmsley (5 plates, 27 text-figures). A systematic description of the vascular system of a female fetal finback 1430 mm. long. This is supplemented by histological accounts of many of the tissues.

Ovaries of gorilla, chimpanzee, orangutan and gibbon, by Saim Säglük (5 plates). The material forming the basis of this paper comprises the ovaries of three gorillas, two chimpanzees, one orangutan and one gibbon. Comparisons are made with Old and New World monkeys and with human ovaries.

The morphogenesis and histogenesis of the thymus gland in man: In which the origin of the Hassall's corpuscles of the human thymus is discovered, by Edgar H. Norris (7 plates, 1 text-figure).

Multiplication and reduction of somatic chromosome groups as a regular developmental process in the mosquito, *Culex pipiens*, by Charles A. Berger (1 plate, 10 text-figures).

The history of the first somite in human embryos, by Leslie B. Arey (1 plate, 2 text-figures).

Bodily growth of babies during the first

postnatal year, by Charles B. Davenport (1 text-figure, 4 tables, 13 graphs). This last study in this series is statistical in nature and summarizes the results on 34 babies, measured repeatedly in 49 dimensions during the first year of postnatal life.

All of these papers are accompanied by literature lists. It is hardly necessary to point out that the technique and execution of the illustrations are excellent.



THE EMBRYOLOGY OF THE OPOSSUM. *The American Anatomical Memoirs* No. 16.

By Edward McCrady, Jr. *The Wistar Institute of Anatomy and Biology, Philadelphia*. \$5.00. 10 x 6½; 234; 1938 (paper).

The Virginia opossum (*Didelphis virginiana* Kerr) is an extremely abundant primitive marsupial and is easily caught in almost every part of the United States from about the latitude of Pennsylvania south. It is, however, difficult to domesticate and not until bone meal was added to the diet did the rachitic conditions, developed in domesticated opossums, disappear.

Starting with descriptions of the ovarian egg and testicular sperm the author minutely describes the 35 stages of embryonic development from the time of fertilization to the time of parturition 12½ days later. The post-natal development in the 80-day period of "pouch-housing" following birth is also described. Various researches on the development of hearing in the newborn opossum and experiments on the opossum embryos near birth are discussed. In all cases the experimental techniques are given.

The evidence obtained by the author seems to support Huxley's theory that the Prototheria split into two branches, one of which became the modern Monotremata, the other giving rise to the Metatheria which in turn split to form the modern Marsupials and the Eutheria. The author does not believe that the marsupials are the result of a degeneration from a eutherian condition.

In addition to 3 plates showing the 35 stages of development, there are many other illustrations which are completely

explained in the text. There is an extensive bibliography.



BIOGRAPHY OF THE UNBORN.

By Margaret Shea Gilbert. Williams & Wilkins Co., Baltimore. \$1.75. 8½ x 5½; x + 132; 1938.

The development of the human organism from a helpless single-celled fertilized ovum to a many-celled eight pound bawling baby is a drama full of mystery, fact and fiction. The process of embryological development has always been an absorbing study, but to the layman who is anxious to learn about his intrauterine history the mass of accumulated facts are too recondite and scattered to satisfy his curiosity. The author of this book comes to the rescue by presenting the biography of the embryo from conception till birth in a non-technical, yet substantially accurate, manner. The progressive development of the embryo is taken in nine stages, one for each month of gestation. Fertilization, implantation, placental interchange, and birth, besides the actual process of growth of the various systems of the fetus itself, are intelligibly described. Numerous drawings help to illustrate the text.

Out of sixty-one entries, Mrs. Gilbert's was chosen to receive the award offered by the publishers for the best manuscript on a science subject calculated to interest the general reader.



ÉLÉMENTS D'EMBRYOLOGIE.

By A. Celestino da Costa. Masson et Cie, Paris. 120 francs. 9½ x 6½; viii + 494; 1938 (paper).

Originally this work was published in Portuguese in 1933. Being a textbook for medical students, it emphasizes human embryology and contains numerous sections devoted to pathological conditions and anomalies of development. The first part of the book treats of gametogenesis and Mendelian heredity, thus furnishing an excellent biological background to the further sections on embryology in general and the more specific formation of the

various organ systems. The appendix is a compendium of historical studies in the subject. A well-illustrated text.



THE NERVOUS SYSTEM. A Guide for Use with the Educational Sound Picture "The Nervous System."

By James A. Brill in collaboration with Frederick T. Howard and Ralph W. Gerard. University of Chicago Press, Chicago. 15 cents. 8 x 5½; iv + 30; 1938 (paper).

This study guide is issued in connection with an educational sound picture on the nervous system. It deals briefly with: Functions of the nervous system, major divisions of the nervous system, structure of the nerve, structure of the nerve cell, connections of nerve cells with one another, nature of nerve impulses, relation of the nervous system to the whole body, comparative anatomy of the nervous systems of man and other vertebrates, and nature of neural pathways.



INDIVIDUALITÄT UND FORTPFLANZUNG ALS POLARITÄTSPHÄNOMEN. Die Herabwanderung der Keimdrüsen der Säugetiere im Lichte organismischer Auffassung.

By Armin Müller. Introduction by J. H. Schulz. Concluding remarks by A. Portman. Verlag von Gustav Fischer, Jena. RM. 3. 9½ x 6½; [8] + 66; 1938 (paper).

This is a discussion of various theories on the descent of the mammalian gonads, such as Steiner's law of "migration to the head end," Monokow's view of "migration to the frontal pole," physical dominance and subordination (Cuvier, Child, Mittasch), "specific psychic valence" of organs (v. Weizsäcker), and others. The author himself leans toward the architectonic (structural) view. The book is documented, replete with quotations, and there is an index of authors and subjects.



PHYSIOLOGY AND PATHOLOGY

VITAL ENERGETICS. A Study in Comparative Basal Metabolism. Carnegie Institution of Washington Publication No. 503.

By Francis G. Benedict. *Carnegie Institution of Washington, D. C.* \$2.00 (paper); \$2.50 (cloth). 10 x 6½; vii + 215; 1938.

Studies in evolution and genetics have dealt almost entirely with structural form, with some emphasis upon function, but with little, if any, consideration of the most characteristic phenomenon of life, that is, the production of heat. It is our effort to compare with the present-day data available the heat production of animals of various forms, including not only cold-blooded animals but especially warm-blooded animals and likewise those that are heterothermic, the hibernating animals. For the purpose of our discussion we are confining ourselves exclusively to the higher forms of life which are characterized by striking differences in structure or form, differences demanded by the requirements of the organisms to adjust themselves to the different conditions, either of temperature or of the character of vegetation, temperature affecting external conditions such as fur and fatty deposits and the character of the feeds affecting the digestive system.

Only a brief listing of some of the important findings can be given which by no means indicate the scope of the work.

First, in general the larger the animal the larger the total heat production. Secondly, as has been known for decades, the heat production is not constant per unit of weight, and thirdly, it is clearly demonstrated that the heat production is not constant per unit of surface area. . . . From the various comparisons of animals in the same species and in the same weight group, the sex difference *per se* is accentuated as perhaps never before. This is notably the case with men and women and with the bovines, and there is also a hint of a sex difference in the adult pig and goat, although the data are as yet not complete enough to more than suggest this. In each case the difference in metabolism is pronounced and demands an explanation other than any possible slight differences in surface area. . . . *With different species* in the same weight group there are great differences in the total heat production, and in the metabolism expressed per kilogram and per square meter. . . . Another factor to be taken into consideration is the variability of the basal metabolism, shown in a number of animals, notably the ruminants. This variability may be in great part a factor of food. A most striking illustration is the difference in the metabolism of cows that had been grazing and the same cows when fed dry rations. . . . Closely related to the effect of food, which in the last analysis, may be considered perhaps a type of stimulus, are the effects of varying stimuli on metabolism. . . . The suggestions enumerated above apply specifically to the warm-blooded group and by no means exhaust the possibilities for thought. With the poikilotherms the situation is different, for the type of thermic reaction is different, in that there is no zone of thermic neutrality. . . . In these animals [heterothermic], certainly in the marmot, the temperature relations are different from those obtaining with other warm-blooded animals, and the Q_{10} law, which holds so

rigidly with the cold-blooded animals, does not obtain, save at higher cell temperatures.



MAN AND HIS BODY.

By Howard W. Haggard. *With an Introduction by Yandell Henderson.* Harper and Brothers, New York. \$4.00. 8½ x 5½; xiii + 594 + 9 plates; 1938.

THE SCIENCE OF HEALTH AND DISEASE. A Textbook of Physiology and Hygiene. Revised Edition.

By Howard W. Haggard. Harper and Brothers, New York and London. \$3.00. 8½ x 5½; xiii + 594 + 9 plates; 1938.

These books are simple, non-technical presentations of applied physiology. Haggard has done a good job of making understandable material which, to the reader unversed in science, usually seems to be written in the foreign language of biological terminology. Enough anatomy has been included to furnish a clear foundation for the discussion of bodily functions in health and in disease. No doubt the penetrating reader will be aroused to pose further questions for his family doctor to answer, and perhaps the suggestible patient will develop new aches and pains for him to treat.

It is puzzling to note that the "revised edition" of the second book seems to be like the first edition except in the title page and price, and in its designation as a textbook. Those who enjoyed the earlier edition would be pleased to find in *The Science of Health and Disease* more of the same material. So they will, but in a literal sense. This seems to be the same book (*Man and His Body*) over again.



THE WHEEL OF HEALTH.

By G. T. Wrench. C. W. Daniel Co., London. 6s. net. 8½ x 5½; 146; 1938. The three transferences from soil to vegetable, vegetable to animal, animal and vegetable back to the soil, constitute the eternal wheel of health in the eyes of the author. He is a thorough-going nutritionist, considering proper food as the panacea for all ills, human and otherwise.

In a valley walled by mountains three

miles high, where India meets Afghanistan, may be found the State of Hunza. This valley is a sort of "Lost Horizon," for in it dwell people of extreme physical vigor, endurance, and length of life. The author wanted to break away from the pathological or negative study of health and approach it from the opposite end of the scale—the healthiest people he could find—the Hunza. His writing is based on the work of Dr. Robert McCarrison who studied deficiency diseases in India and transferred the human studies to whole-diet experiments on rat populations. On the basis of these experiments Wrench concludes that the causes of pneumonia, middle-ear infection, and peptic ulcers are respectively faulty food, faulty food, and primarily faulty food. Why the concession?



MARIHUANA. *America's New Drug Problem. A Sociologic Question with Its Basic Explanation Dependent on Biologic and Medical Principles.*

By Robert P. Walton. Foreword by E. M. K. Geising and a chapter by Frank R. Gomila and M. C. Gomila Lambou. J. B. Lippincott Co., Philadelphia. \$3.00. 9 x 6; ix + 223 + 13 plates; 1938.

This book is much better than its jacket and title might lead one to suppose. Popular songs, fiction, and newspaper and magazine articles have painted a lurid picture of marihuana. What is fact, what fancy, has been difficult to decide without a study of reports in scattered scientific journals, together with the account of *Cannabis* in textbooks of pharmacology. This monograph makes easily accessible the data from such sources. It offers no solution to "America's new drug problem," but does present a basis for an attack on it.

Opening his study with a history of the hashish vice and a description of the hemp plant, the author proceeds to analyze the chemical and pharmaceutical properties of the drug. In other chapters he summarizes the observations of various workers on its biological effect, which "is probably due to the removal of the usual restraints and correspondingly to

the release of the more primitive impulses." The descriptions of hashish experiences make colorful reading.

The section contributed by the New Orleans Public Safety Commissioner is timely. It is interesting to note that "the most serious aspect of the marihuana problem is the extent to which the vice contributes to juvenile delinquency, serves as an introduction to other more-potently addicting drugs, and conditions the petty criminal to perform truly desperate acts of violence."



BIOLOGY AND PATHOLOGY OF THE TOOTH AND ITS SUPPORTING MECHANISM.

By Bernhard Gottlieb and Balint Orban. Translated and edited by Moses Diamond. The Macmillan Co., New York. \$5.00. 9½ x 6; xii + 195; 1938.

Much of what has been looked upon as disease manifestations now looms up as regularly occurring physiologic processes. One cannot minimize the import of a correct evaluation of the normal physiologic mechanism in an understanding of disease. The study of the disease manifestations of the periodontal tissues by Gottlieb and Orban is therefore based upon their reevaluation of the normal. Traumatic occlusion ceases to be a clinical entity subject to whimsical interpretation.

The above is quoted from Dr. Diamond's preface. He considers this work to be so important for routine dental practice that he hopes it will become known to the dental profession generally.

The book includes chapters on the supporting mechanism of the tooth; accelerated tooth eruption; gingival inflammation, Schmutz pyorrhea; parodontal pyorrhea; diffuse atrophy of the alveolar bone; and traumatic occlusion. Attention is particularly called to the authors' concepts "of the gingival crevice, and of the physiologic mechanism of continuous eruption" and "of the continuous deposition of cementum as a physiologic process, and of the tooth as the vital organ to the needs of which the surrounding and supporting tissues are subservient."

Dental anatomists who have heard of the investigations of Gottlieb and Orban will welcome this translation of the contributions which these Viennese workers made prior to their migration to America.

Diamond has made some additions to the text.



GUINEA PIGS AND BUGBEARS.

By G. L. Eskew. *Research Press, Chicago.*
\$1.50. 8½ x 5½; [10] + 269 + [3]; 1938.

Two hundred and sixty-nine pages of Mr. Eskew's book are devoted to a bitter personal attack on the organizers and officers of institutions for consumer guidance. No rhetorical technique of satire and belittlement is spared in this adverse criticism, whether or not it is justifiable. One of the consumer bulletins ("BULLETINS" as Mr. Eskew puts it) issued a statement concerning the harmful effects of tobacco. *Guinea Pigs and Bugbears* answers by associating the increased use of tobacco with the facts that college boys and girls now average two inches taller and seven pounds heavier than they did forty years ago, and life expectancy of the average American is now 61 years as compared to 38 a century ago.

It is regrettable that abundantly deserved criticism of much of the "consumer research" material going to the public is not more temperately stated.



HIBERNATION AND MARMOT PHYSIOLOGY.

Carnegie Institution of Washington Publication No. 497.

By Francis G. Benedict and Robert C. Lee. *Carnegie Institution of Washington, D. C.*
\$2.00 (paper); \$2.50 (cloth). 10 x 6½; x + 239; 1938.

A painstaking survey of the physiological processes of the ground-hog is embodied in this volume. Although natural hibernation was not simulated as closely as one could wish, the task was difficult because of the conditions necessary for careful measurement of weight, temperature, heart rate, respiration, vaporization, and nitrogen secretion. As is often the case, the very absence of normal conditions brought to light several interesting features, one of these being that marmot hibernation is not due merely to seasonal effect, but by artificial influence may be

induced at any time of year. The normal physiology of the non-hibernating animal is greatly altered during the hibernating period. Depending on environment the body temperature during hibernation may go as low as 3°C., the respiration rate may descend to 1 in 5 minutes, and the heart rate to 4 per minute. The waking process causes an explosive increase in physiological activity far above that of the normal non-hibernating marmot. Causes and theories of hibernation are discussed in the final pages, and comparisons are made among different animal forms.



FORSCHUNG ÜBER DIE TUBERKULOSE DES LANDWIRTSCHAFTLICHEN BEZIRKES. Rassenbiologische Untersuchungen des hygienischen Instituts an der medizinischen Fakultät zu Kanazawa. Number 6. Under the direction of Prof. Dr. Y. Koya.

Edited by Y. Koya. *Hygienisches Institut an der medizinischen Fakultät, Kanazawa, Japan.* 10½ x 7½; 239; 1938 (paper). [In Japanese.] [Separate in German: "Beitrag zur Erforschung der Tuberkulose unter der Landbevölkerung in Japan," by Y. Koya. Pp. 10.]

Among the findings of this study on tuberculosis in the rural areas of Japan is that the mortality rates from this disease were higher in rural areas near the cities than in the cities themselves, but that they decreased with distance from urban centers, and were very low indeed in the mountain regions. The author explains these differences in the following way: in the cities, although the infecting agents are more prevalent, preventive measures of various kinds are also more common; in rural areas the causal organism is not of such frequent occurrence but the population is not well equipped to defend itself against it (some rural inhabitants also go to town to work in the factories and contract the disease there); in areas distant from cities and in the highlands the tubercle bacillus is rarely present.

Those interested in tuberculosis epidemiology would doubtless find much of interest in this book were it written in a language more widely known than Japan-

esc. The German supplement contains only a part of the investigation and results.



EFFECT OF CHRONIC VITAMIN E DEFICIENCY ON THE NERVOUS SYSTEM AND THE SKELETAL MUSCULATURE IN ADULT RATS. *A Neurotropic Factor in Wheat Germ Oil.*

By Lårus Einarson and Axel Ringsted.

Levin and Munksgaard, Copenhagen; Oxford University Press, London. Kr. 12.50.

9½ x 6½; 163; 1938 (paper).

"In this work 'vitamin E-free diet' always means a food mixture very poor in vitamin E but dependent upon the greater or smaller amount of vitamin E contained in the integrant components of the diet and the destruction of this vitamin in being mixed and stored with the oxidised lard."

In a survey of the results of their work the authors point out that (a) the gross picture of the muscular changes points decidedly to a muscular atrophy of spinal origin—a neurogenous muscular atrophy—but that they have been unable to exclude the possibility that the muscular changes may in part be dystrophic and partly be due to the spinal changes, (b) that the vitamin E deficiency might influence not only the cerebrospinal nervous system but also the sympathetic nervous system and that "it is conceivable that the testicular degeneration thus eventually may have to be considered as a neurogenous phenomenon." Numerous figures exhibit the cytological effects of the experiments, and the study concludes with a bibliography of about 70 titles.



DIE PHYSIOLOGIE DER FISCHATMUNG.

By Michael Leiner. Akademische Verlagsgesellschaft, Leipzig. 12 gold marks.

10 x 6½; 134; 1938 (paper).

This interesting and profusely illustrated book is a thorough study of the breathing mechanisms of fish. The first chapter discusses water as an environmental factor and the blood as transporter of respiratory gases. Further chapters treat the anatomical and histological structure of the gills

and their function as respiratory organs, embryonic respiration, the functions of auxiliary breathing organs such as the skin, membranes of the mouth and throat (air respiration of the labyrinth fishes and of *Amphioxus* and *Electrophorus*), intestines, and swimming bladder. Those remarkable specimens, the lung fishes, Polypterids and Dipnoi receive discussion. The concluding chapter deals with the function of the pseudobranchia, the acidophile cells in all the breathing organs of fish, and the gland cells of the swimming bladder. The bibliography comprises 313 titles.



FOOD CONSUMPTION OF CHILDREN AT THE NATIONAL CHILD RESEARCH CENTER. U. S. Department of Agriculture. Circular No. 481.

By Helen Nebeker Hann and Hazel K. Stiebeling. Government Printing Office., Washington. 10 cents. 9½ x 5½; 34; 1938 (paper).

In order to obtain data on the food-consumption habits and the nutritive value of diets of healthy young children, quantitative studies of the food consumed by children at the National Child Research Center, Washington, D. C. were made during the period 1931-36 on children from 24 to 71 months old. The authors report on the type of food served at school, the quantity of various foods eaten, the energy value of the food consumed by the children at home and in school, the nutritive value of the meals served at the nursery school, the distribution of calories among specified classes of food, and the cost of the food served at the nursery school. Frequent tables, an appendix, and a bibliography supplement the text.



SYPHILIS. Presented by the Section on the Medical Sciences. Publications of the American Association for the Advancement of Science No. 6.

Edited by Forest R. Moulton. The Science Press, Lancaster, Pa. \$2.50. 10½ x 7½; 193; 1938.

The third of the symposia on public health

problems organized and presented by the Section on Medical Sciences of the A. A. A. S. is devoted to the study of syphilis, one of the most serious health problems in the United States. This symposium consists of thirty papers by thirty-two authors, all of whom are leading specialists in the various fields connected with the study of this disease. In its entirety, this publication presents an excellent systematic summary of the present knowledge of syphilis.



SCHAFER'S EXPERIMENTAL PHYSIOLOGY.
Sixth Edition.

By *W. A. Bain*. Longmans, Green and Co., New York and London. \$2.40.
8½ x 5½; viii + 184; 1938.

In this edition a good deal has been added to the sections on involuntary muscle, the heart, the circulation, and the special senses. The text, which contains precise directions for performing most of the fundamental experiments in physiology except those of a chemical nature, has been thoroughly revised.



A GUIDE TO HUMAN PARASITOLOGY for Medical Practitioners. *Third Edition.*

By *D. B. Blacklock and T. Southwell*. William Wood & Co., Baltimore. \$4.00.
9½ x 6½; viii + 259 + 2 plates; 1938.

In general this text (with the exception of being brought up to date) remains in the same form as the earlier edition. The chapter on malaria has been entirely rearranged and the section on leishmaniasis largely rewritten.



BIOCHEMISTRY

INSULIN: Its Chemistry and Physiology.

By *Hans F. Jensen*. The Commonwealth Fund, New York; Oxford University Press, London. \$2.00. 9 x 5½; xii + 252; 1938.

A concise but comprehensive review and evaluation of most of the important literature on the chemistry and physiological

action of insulin. Since a vast literature has accumulated in this field of research, the author has given preference to the more recent researches on insulin and has recorded literature up to January 1, 1938.

The monograph is divided into seven chapters, each concluding with an extensive bibliography, and dealing in the following sequence with: (1) the history of insulin including early investigations on the relationship between the function of the pancreas and diabetes and early attempts to prepare pancreatic extracts; (2) the methods of preparation and purification of insulin and sources of insulin in tissues other than the pancreas; (3) the preparation and chemistry of crystalline insulin starting from 1926 when Abel and his associates first obtained the hormone in its crystalline form and demonstrated its protein-like nature; (4) the standardization of insulin; (5) the different modes of injecting insulin; (6) the many insulin substitutes and their therapeutic value; and (7) the physiological action of insulin. The investigations made by the author and his associates in the chemistry of insulin are included in this book.



DIE ELEKTRISCHEN GRUPPEN IN BIOLOGIE UND MEDIZIN (with an English Summary).

By *Rudolf Keller*. Sperber-Verlag, Zürich.
3 francs. 9½ x 5½; 92; 1938 (paper).

This brief résumé of some of the literature on electrical analyses of human organs and tissues in health and disease was prepared in the hope of encouraging further work, and of interesting chemists, physiologists, and medical men in the study of measurements of electric qualities of the minerals of body tissues as an aid to diagnostic work. Some diseases are claimed to be due to an upset of normal electric balance. From this point of view individual chapters—some but two pages in length—treat pregnancy, minerals of the eye, the kidneys, nerves, blood, invisible circulation in the connective tissues, etc. The book is documented and there are appended a brief literature list and a quotation in English of Franz Goldmann's (Prague) "The importance of the mineral groups for the understanding of physiological and pathological states during infancy."

GRUNDRISS DER HISTOPHYSIOLOGIE. *Allgemeine Methoden und Probleme. Probleme der Biologie, Band 2.*

By *Erich Ries*. Akademische Verlagsgesellschaft, Leipzig. 26 gold marks. 8½ x 5½; xii + 413; 1938.

This, the second volume of the *Probleme der Biologie* series, brings together and correlates (1) the various methods of histological technique, and (2) the differentiation, behavior, and properties of cells and tissues *in vivo* and *in vitro*. Some problems such as the permeability of the membranes, the germ cells and fecundation are treated summarily, whereas vital straining, histochemistry and the physicochemical techniques receive more space. The bibliography covers 45 pages, and there are author and subject indices.



THE DETERMINATION OF THE AMINO ACIDS. *Revised Edition.*

By *Richard J. Block*. Burgess Publishing Co., Minneapolis. \$2.00. 10½ x 8½; [8] + 91; 1938.

It is the author's opinion that of the 22 recognized amino acids only the following 12 can be estimated with a fair degree of accuracy: arginine, cystine, glycine, histidine, diiodotyrosine, lysine, methionine, phenylalanine, proline, thyroxine, tryptophane and tyrosine. In the second printing of this monograph corrections of errors in the first edition and modifications of some of the descriptions of methods have been made.



BIODYNAMICA. *A Journal for the Study of the Nature of Life (Structure and Dynamics of Living Matter).* Nos. 34-37 and 38-43.

Edited by *Basile J. Luyet*. Biodynamica, Normandy, Missouri. 9½ x 7; Nos. 34-37, 60; Nos. 38-43, 56; 1938 (paper).



SEX

PLAN FOR MARRIAGE. *An Intelligent Approach to Marriage and Parenthood. Pro-*

posed by Members of the Staff of Vassar College.

Edited by *Joseph K. Folsom*. Contributors: *Mary S. Fisher, Beatrice B. Berle, J. Howard Howson, Joseph K. Folsom, Raymond Squier, Ruth E. Conklin, Gladys B. Jones*. With a Foreword by *Henry N. MacCracken*. Harper and Brothers, New York and London. \$3.00. 8 x 5½; xii + [2] + 305; 1938.

For various and well-known reasons, sex behavior in general has only in recent years become the subject of more or less open discussion. Lately the movement which seeks to spread accurate knowledge about the several aspects of the interrelations between the sexes has reached the schools and in some colleges courses on marriage have become a more or less established part of the curriculum. One of the most publicized of these is that given at Vassar College and in this book the seven teachers responsible for it present the substance of their lectures. M. S. Fisher contributes three chapters dealing respectively with the place of romance in love and marriage, the employed married woman and parenthood. Three other chapters have been written by J. H. Howson who deals with the questions of intelligence, emotional maturity and religion in relation to marriage. The editor, J. K. Folsom, in two chapters, writes on marital selections and the future of the marriage institution. B. B. Berle, G. B. Jones, R. Squier, and R. E. Conklin have each contributed a chapter. The technique of intra-marital harmony is discussed by the first, the budget by the second writer, sex physiology is outlined by the third writer, and the fourth summarizes what is known about the anatomy and physiology of reproduction. Altogether, this volume demonstrates the competence of the writers but the chapters prepared by the last three named stand out. The reason is obvious. They concern phenomena about which there is a certain amount of real knowledge. The same cannot be said about the aspects of marriage treated in the other chapters; consequently these articles smack too much of the sermon and convey the personal ideals of the writer rather than objective information about the matter.

PRACTICAL BIRTH-CONTROL METHODS.

By Norman E. Himes, with the medical collaboration of Abraham Stone. Introduction by Robert L. Dickinson. Foreword by Havelock Ellis. Illustrations by Irving Geis. *Modern Age Books*, New York. 95 cents. 8 x 5½; [14] + 254; 1938 (paper).

The purpose of this manual is to help the individual seeking contraceptive advice to find a competent doctor and to supplement the oral instructions he (or maybe she, says Reginald the Office Boy) will obtain with printed information enabling the more intelligent application of such instructions. Himes aims to present certain general information too detailed for a doctor to offer in an interview, but calculated to allay unnecessary fears resulting from insufficient knowledge of sexual matters.

In this complete, thorough, and well-written volume the author, with the medical collaboration of Dr. Abraham Stone, has succeeded admirably in accomplishing his purpose, and deals in a scholarly fashion, though not without humor, with all the pertinent information. The medically approved methods used today are separately described, evaluated and illustrated by accurate and simplified drawings. A valuable chapter on Household Methods has been added for the benefit of those living in rural districts inaccessible to medical help. The dangers of harmful, ineffective and much advertised methods of Feminine Hygiene are pointed out, and the fundamentals of sex anatomy and physiology are briefly and clearly discussed.

An historically interesting chapter is that on primitive methods of birth control, while other chapters give brief histories of its more modern crusaders and discuss the steps that have been taken to modify the legal attitude toward birth control in the United States. Further chapters discuss sterilization, abortion and the Russian experiment. Appendices include a list of the United States birth control-centers according to states, a list of the trade names of approved contraceptives, and a glossary. Also included is a complete index and suggestions for further reading.

THALASSA: A Theory of Genitality.

By Sándor Ferenczi. Translated by Henry A. Bunker. *The Psychoanalytic Quarterly*, Albany, N. Y. \$1.75. 9 x 6; v + 110; 1938.

In this book a psychoanalytic interpretation of the act of coitus in human beings is presented. The subject matter, an outgrowth of reflections by the author, is developed in three sections. The first section is concerned with the ontogenetic significance of coitus, the thesis being that each act of coitus is basically a symbolic return of the male, and of the female through identification with the male, to intrauterine existence. The second section advances a phylogenetic interpretation of coitus, namely that each act of coitus in reality represents a return of the individual to that period in evolutionary history before the recession of the ocean, when life was essentially aquatic. In the final section the possibility of the origin of the two sexes as an adaptation to land life is discussed from the psychoanalytic viewpoint. The author's argument appears to be something less than quite incontrovertible, but will be of interest to psychiatrists as an example of psychoanalytic reasoning.

**DER ZYKLUS DER FRAU. Reform des Ehelebens.**

By Jules Samuels. G. Naeff, *The Hague*. Gld. 4.50 (paper); Gld. 5.50 (bound). 9½ x 6½; 174; 1938.

The author here describes and explains the mechanism and operation of the cyclo-scope—the principal part of which is a spectroscope—perfected by him in 1937, and reputed to (a) determine exactly the date of ovulation in women; (b) to diagnose within a few days after the event, the fertilization of an ovum; and (c) to present graphically all ovulatory and menstrual variations. His results, also presented in this book, oppose the current "safe-period" theories in that the cyclosopic studies support the theory that ovulation in the human female occurs twice (and sometimes even three times, especially in young nullipara) during the menstrual cycle, the first usually occurring

on the ninth to twelfth day, and the second on the sixteenth to eighteenth day. The "fertile period" is therefore given as from the third day before the first ovulation to three days after the second.

The publications of the author on this subject—25 articles and three books from 1937 on!—alone serve as bibliography.



CONTROL OF CONCEPTION. *A Clinical Medical Manual. Second Edition.*

By Robert L. Dickinson. Williams & Wilkins Co., Baltimore. \$3.50. 9 x 6; xiv + 390; 1938.

Dr. Dickinson's name alone appears on the cover of the revised edition (cf. Q.R.B., Vol. 7, No. 3 for mention of first edition) of this standard and valuable manual. When compared with the earlier editions we note a good many changes in the drawings and arrangement of subject matter and the addition of much new material. A number of special contributors have written on such subjects as hormonal control, sperm immunity, and the "safe" or sterile period, and the results of important recent studies have been incorporated in many sections of the book. An excellent guide for the teaching and practising physician.



CONTRIBUTIONS TO FATE ANALYSIS. I. Analysis of Marriages. An Attempt at a Theory of Choice in Love.

By L. Szondi. Martinus Nijhoff, The Hague. Gld. 2.80. 9½ x 6½; 80 + 7 plates; 1938 (paper).

This book is offered as the first in a series designed to elevate "erology" or the science of love, to a place among the exact sciences. The author advances the theory that attraction between individuals is strictly the result of the possession by each of common recessive ancestral genes which act as "natural matchmakers." This argument seems rather naively conceived, and is not very convincingly supported by the case records and genealogical data which the author presents. There is no index or bibliography.

BIOMETRY

STATISTICAL METHODS FOR RESEARCH WORKERS. *Seventh Edition, Revised and Enlarged.*

By R. A. Fisher. Oliver and Boyd, Edinburgh and London. 15s. 8½ x 5½; xv + 356; 1938.

Professor Fisher has made two changes in this latest edition of his well-known text which should be noted. The section on "Fitting of curved regression lines" has been expanded so as "to give a fuller introduction to the theory of orthogonal polynomials, by way of orthogonal comparisons between observations"; and in the chapter on analysis of variance, a new section dealing with the discrimination of groups by means of multiple measurements has been added. The numbers of sections, tables and examples have been unaltered by the insertion of fresh material, so that references to them are valid for all editions.



INTRODUCTION TO ECONOMIC STATISTICS.

By William L. Crum, Alson C. Patton and Arthur R. Tebbutt. McGraw-Hill Book Co., New York and London. \$4.00. 9 x 5½; xi + 423; 1938.

A complete revision of an excellent book which first appeared in 1925 (cf. Q.R.B., Vol. 1, p. 135). New parts have been added and certain "materials which appear now appropriate for more advanced texts have been eliminated or reduced in emphasis. The intent throughout has been to preserve the elementary character of the treatment." The sections of the book are as follows: Statistical data; general and analytical methods; the analysis of time series; a group of 4 appendices, and an index.



STATISTICAL METHODS Applied to Experiments in Agriculture and Biology. [Revised.]

By George W. Snedecor. Collegiate Press, Inc., Ames, Iowa. \$3.75. 8½ x 5½; xiii + 388; 1938.

This edition follows very closely the original (noticed in Q.R.B., Vol. 13, No. 3) except that either by elimination or con-

densation of material it is shorter by 46 pages. The brief time between the appearance of the two editions indicates the usefulness of this text.



PSYCHOLOGY AND BEHAVIOR

THE REDISCOVERY OF MAN.

By Henry C. Link. *The Macmillan Co.*, New York. \$1.75. 7 $\frac{1}{4}$ x 5 $\frac{1}{4}$; ix + 257; 1938.

Here is a book which many will wish to read, but few will wish to own; which many will discuss but few remember.

The author is a practical psychologist, which means that he treats psychiatric cases, but he does not call himself a psychiatrist for he reserves that term for those who have had medical training. This does not imply that the author has had no medical training, but only that he does not believe a knowledge of medicine necessary to a successful treatment of psychiatric cases.

Link believes that there are two contrasting types of personality—the introvert and the extrovert. In concrete instances these two are mixed in varying proportions. The value of any influence is to be determined by the type of personality to which it ministers. Influences that make for introversion are bad and should be avoided, while those that make for extroversion are good and should be cultivated. Thus bridge is a good game because it involves four participants, and chess is a bad game because it involves only two. Orchestral music is good, because it involves an entire orchestra, but the piano is an independent instrument and its use should be discouraged except as an instrument of discipline.

As the present reviewer reads this book, he becomes increasingly aware that his own personality embodies practically all those traits that Dr. Link considers objectionable, and so enters upon his task with a certain amount of prejudice which readers should bear in mind when discounting his conclusions. Yet the reviewer must admit that the author hits the nail on the head with somewhat greater frequency than one would expect were his aim controlled by

mere chance. Perhaps he was aiming at a different nail. He is at his best in matters of absolute theology—his discussion of the character of Jesus in his closing chapter is both sound and sane—one wonders why it was not placed at the beginning of the book. But when he comes to the application of the example of Jesus to modern problems of social misplacement he seems to go sadly astray.

The social misfit is personality that is not adjusted to its environment. The adjustment may, in theory, be made either by altering the personality or the environment. But as the environment contains many personalities, and is therefore more complex than any individual personality, Link believes the adjustment can be made more expeditiously by altering the personality, and calls the practice of Jesus to witness. It is true that Jesus did work profound changes in personalities of those with whom He came into intimate contact, but it is clear that many of these were to meet emergencies (i.e., the healing of the lepers and the man with the palsy and the casting out of devils) and He made no use of these in His teaching—in fact in one instance He enjoined his patient to say nothing of what had occurred. The oft-quoted statement "Ye must be born again" was only a means to an end—it was addressed not to the social misfits, but to those who considered themselves in complete adjustment. Had all of these been spiritually reborn a rather revolutionary change in the environment would have been the result.

Of course, the value and efficacy of Dr. Link's treatment must be judged by the results obtained in practice and not by theories expounded in books, and it may well be that his practice is superior to his theory. But one cannot help feeling that his philosophy is dangerously near to the pessimism of John Vance Cheney, who implies that the System was not made for man, but that man was made for the System, as in his poem inspired by Millet's painting "The Man with the Hoe" when he declares that the laborer was

Cast for the gap, and gnarled in arm and limb
The mother molded him.
Yes, since above his work he cannot rise
She makes the fields his skies.

PERSONALITY STRUCTURE IN SCHIZOPHRENIA.
A Rorschach Investigation in 81 Patients and 64 Controls. Nervous and Mental Disease Monograph No. 63.

By Samuel J. Beck. Preface by C. Macfie Campbell. Nervous and Mental Disease Publishing Co., New York. \$2.00. 9 x 6; ix + 88; 1938.

This book presents the results of a study of 81 schizophrenic patients at the Boston Psychopathic Hospital and 64 non-psychotic controls by means of the Rorschach ink-blot test. The nature of the test, the procedure for administering it, the method of scoring the patient's responses, and sample responses of patient and control form the subject matter of the first four chapters. The statistical findings in the material of this study are then presented and the psychological implications discussed. The author feels that the Rorschach test is valuable not only as an objective aid in differential diagnosis, but also in elucidating the structure of the schizophrenic personality. Some of the conclusions to which test results lead in this respect are presented in the remaining chapters. It was found that, relative to the controls, the schizophrenic patient stands significantly lower in appreciation of reality, significantly higher in affect, with not much difference in grasp of relationship and in imaginative living.

This study is a valuable contribution to the problem of the schizophrenic personality, both as a demonstration of the possibilities of the Rorschach technique and in the specific conclusions emerging from its application in this particular sample of schizophrenic patients. There is an index and a brief bibliographical note.



MODERN SOCIETY AND MENTAL DISEASE.

By Carney Landis and James D. Page. Farrar and Rinehart, Inc., New York. \$1.50. 8 x 5½; xi + 190; 1938.

In this excellent book, written from the biosocial viewpoint, the authors have utilized data obtained from public records in this country and in Europe, as a basis for studying the relationship of mental disease to such important factors as sex, age, education, economic status, social

status, and environment. Such controversial questions as marriage, eugenics, and sterilization in relation to mental disease are considered in a practical way. The interesting conclusion is reached that if the two groups of mental patients in which hereditary factors seem to operate to some extent (manic-depressive and dementia praecox) were sterilized at the time of first admission to hospital, the incidence rates for the former would be reduced only from 1.1 to 2.4 percent in the next generation, and for the latter from 2.2 to 3.3 percent. The material in this book supports the argument that etiologic factors in mental disease are basically physiological and constitutional rather than psychological. Interesting data are likewise presented on outcome of mental disease and on the increasing incidence of mental disease. There is an appendix and a bibliography of 115 titles.

THE BEHAVIOUR OF ANIMALS. *An introduction to its Study. Second Edition.*

By E. S. Russell. Edward Arnold and Co., London; Longmans, Green and Co., New York. \$4.20. 8½ x 5½; viii + 196 + 6 plates; 1938.

The second edition of this work is practically unchanged from the previous edition (noticed in Vol. 9, No. 4). One new chapter has been added, however, wherein Russell emphasizes the point that

the animal's perceptual world is essentially a practical or functional one. The animal attends to, perceives, and shows behaviour in respect of, only those events, objects, and characters of objects that are at the moment functionally important to it, those about which it is impelled to *do something*; only these have valence for it. All other features of the environment, which come within its sensory range, constitute what we may call the neutral background of action, and in so far, and at such times, as they are not responded to or dealt with in any way, they must be regarded as not perceived, as having no valence.

This is still one of the best of works to serve as an introduction to the study of animal behavior.



LIFE AND GROWTH

By Alice V. Keliber, with the Commission on Human Relations. D. Appleton-Cen-

tury Company, New York. \$1.20. 7½ x 5; x + 245; 1938.

This book, written for those of high-school and junior-college age and based on a collection of questions asked by the young and assembled by parents and teachers, contains a miscellany of sociology, psychology and physiology. Part One, Human life and social progress, discusses both old ideas and modern scientific ones, intelligence and intelligence testing, pointing out errors in thinking and emphasizing the psychological needs of the individual. Part Two gives some of the fundamentals of heredity, the body and its functions, including an outline on the work of the endocrine glands. An important and skillfully handled section deals with the problem of sex development and sex functioning.

Illustrated by amusing pictorial graphs and photographs, the volume includes suggestions for further reading, a glossary and a complete index.



THE PUPILLARY RESPONSE CONDITIONED TO SUBLIMINAL AUDITORY STIMULI. *Psychological Monographs, Vol. 50, No. 3, Whole No. 223.*

By Lynn E. Baker. *Psychological Review Co., Ohio State University, Columbus.* 50 cents. 9½ x 6½; v + 32; 1938 (paper). Some of the results of this interesting experimental study are as follows:

"The pupillary response can be conditioned to a subliminal auditory stimulus." . . . "The conditioning is accomplished in two stages" . . . "the conditioned disturbance response" [and] . . . "the final form response." . . . "The conditioned connection is more easily established when the conditioned stimulus is subliminal than when it is supraliminal." . . . "The conditioned pupillary response is specific to a high degree." . . . "The disturbance response is less specific than the final form response."

Tables and graphs are given in the text and the paper concludes with 16 references to the literature.



FOX IN THE CLOAK.

By Harry Lee. *Macmillan Company, New York.* \$2.50. 8½ x 5½; 557; 1938. Apart from its interest as a good story,

this novel deserves the attention of human biologists as a penetrating and significant study of adolescence, and of the behavior responses in that period of life to the bewildering and painful stimuli that pour in from the social and the physical environment.



DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

GENERAL SEMANTICS. *Papers from the First American Congress for General Semantics Organized by Joseph C. Trainor and Held at Ellensburg, Washington, March 1 and 2, 1935. With an Introductory "Outline of General Semantics" by Alfred Korzybski, and Other Related Contributions.*

Collected and Arranged by Hansell Baugh. *Arrow Editions, New York.* \$2.00. 11 x 8; 111; 1938 (paper).

The most significant chapter in this symposium is the opening introduction by Korzybski, for one can hardly appreciate a synthetic work of this sort on semantics unless one has some idea as to the significance of this word, and the science of semantics is as yet too young for its name to have become a household word.

Korzybski's thesis is that language is the result largely of environmental contacts, and as man becomes better acquainted with the factors of his environment his language must undergo corresponding modification. But the growth of language is always inordinately slow, so that it lags behind the need that called it forth. As a result, it lacks exactitude, and consequently its elemental terms have different meanings for different people. To a man like Korzybski who speaks fluently five European languages and has probably a working knowledge of several more, the different shades of meanings are more obvious than to one who finds a single language sufficient for his needs. Such an idiom as the double negative in Spanish whose meaning is just the opposite of its literal English translation, or the English phrase "nothing less than" which undergoes a similar reversal of meaning in German are apt illustrations. A friend of the reviewer who was recently driving through Georgia was informed

that he would find the road to be slick, and taking this word to have the same meaning as in his own Colorado, he essayed to negotiate the road, but learned to his dismay that slick in Georgia means not good, but slippery. And how many who are not native Philadelphians know what it means to have a concern, or a stop in the mind?

It is Korzybski's belief that all misunderstandings between individuals as well as between nations result from inexactitude in the meaning of terms, and he longs for a language with the precision of mathematical symbols, so that it will not be necessary to resort to the language of Aristotle and Euclid in discussing the physics of Planck and Einstein. He even goes so far as to venture that many cases of mental derangement due to maladjustments of society might be corrected by the study of semantics, and that the reason that every philosopher appears to have his own peculiar system is due to the ambiguous jargon to which such writers are addicted. They are masters of language in the sense that Lewis Carroll's Humpty Dumpty was, when he declared "When I use a word, that word means exactly what I want it to mean."

The reader will be inclined to speculate as to whether semantics is to become a permanent department of science, or whether it is to share the fate of technocracy, midget golf, Leo Ornstein, diabolos, and Donati's comet. The reviewer is inclined to the former opinion, for the latter enumerated items, with the exception of the last, were talked to death by the Areopagites, and then buried when the novelty had worn off. But the Areopagitic mind is not likely to comprehend semantics.

On the other hand, it must not be forgotten that the art and literature of the ages, and most of the humor as well, has been made possible by the use of idiomatic verbal expression. If we are not satisfied with the way Toscanini interprets a symphony, we are at liberty to listen to Damrosch, Stokowski, or Marcelli. A symphony expressed in mathematical symbols so that all interpretations were exactly alike would *ipso facto* have no in-

terpretations at all. The only composer to attempt to express his compositions in this form was Euler, but it is as a mathematician and not as a symphonist that the world has chosen to remember him. Yet the advantages of an exact language in which every term shall have one and only one signification and in which no two terms shall have the same signification are obvious. Perhaps ultimately it will be found necessary for every one to know two languages—one for science and one for art.



SCIENTISTS ARE HUMAN.

By David L. Watson. With a Foreword
By John Dewey. Watts and Co., London.

7s. 6d. 7½ x 5; xx + 249; 1938.

This book is a condensation of a much longer manuscript that may be obtained in its entirety in microfilm form from the American Documentation Institute. The author himself plainly regards it as an important *magnum opus*. There is justice in this viewpoint because he has literally and honestly put a great part of himself into it. The world's estimate of its significance will probably be in some degree less high, as has not infrequently happened in parallel cases.

The central thesis of the book is, in essence, that a man's scientific work (and, of course, the same is true of everything else he does) is in some degree influenced and colored by the circumstances of his life. To the human biologist this is so obvious a truism that his first reaction is of wonder that 249 pages are necessary to discuss it. Watson's answer is that, in practical fact, not enough attention or weight has been given to this truism in evaluating the work of particular scientific men, or in adequately assessing the significance of science in the life and affairs of humanity generally, or in the organization and conduct of the enterprise of science. There can be no doubt that he has a *prima facie* case on each and all of these counts, and makes it with a good deal of skill and cleverness. But only a certain naivete would suppose scientific men generally do not know quite as well as Watson (or perhaps even better be-

cause more experienced) that some eminent scientists are merely stuffed shirts; that some others are dishonest crooks; that in science as well as in literature, art, or any other human enterprise the correlation between worldly success and intrinsic merit is something less than perfect; or that science or universities have not yet achieved the kind of organization that will automatically ensure that all degrees of genius wherever embodied in human corporeality shall have just and adequate opportunities for realization, expression, and fulfillment. Alas, all these imperfections of the sad world to which we are bound are only too well and widely known—so well understood, in fact, that most men decide that the job of rectification of so sorry a scene is too much for them. Watson is, in contrast, a crusader. We incline to the view that just as it was a mistake for her contemporaries to underrate St. Jeanne so it would be unwise for scientific men not to read *Scientists are Human* now. Apart from, and in addition to, its *Tendency* the book has intrinsic merits. The long Chapter VI "On the similarity of forms and ideas" is a valuable contribution worthy of the most careful study.

The thing our sympathetic and friendly feelings towards the book and its author make us most deplore is a certain note of bitterness that creeps in here and there. This does not help the cause that Watson is promoting. He and his ideas are too big to toy with pettinesses.



MODES OF THOUGHT. *Six Lectures delivered in Wellesley College, Massachusetts, and Two Lectures in the University of Chicago.*

By Alfred N. Whitehead. The Macmillan Co., New York. \$2.50. 7½ x 5; viii + 241; 1938.

It is well known that where copper occurs in nature both in the native state and also in chemical combination it may be recovered more economically in the latter form, for the labor necessitated by the extreme hardness of native copper is greater than that required to decompose copper salts. A rough parallel may be drawn between

the processes of separating pure copper and pure philosophy from their matrices.

Whitehead's philosophical writings are all very highly concentrated—so much so that it is harder to comprehend his philosophy than it would be if it were adulterated with science, art, or religion as so much modern philosophy is. The reader who is accustomed to the assimilation of philosophical literature must continually sharpen the edge of his intellect while reading this book; the reader who is not had best not essay it.

The most characteristic trait of Dr. Whitehead's philosophy is well illustrated by a quotation:

... our bodies lie beyond our individual existence. And yet they are part of it. We think of ourselves as so intimately entwined in bodily life that a man is a complete unity—body and mind. But the body is part of the external world, continues with it. In fact, it is just as much part of nature as anything else—a river, or a mountain, or a cloud. Also, if we are fussy exact we cannot define where a body begins and where external nature ends.

In other words, he aligns himself with the dualists of the past who believed that the great cleavage plane of nature was between mind and body, and opposes himself definitely to the monists of the present who regard mind and body as constituting an indivisible organism, and who find the great cleavage plane to be between the organism and its environment. The philosophers whose writings appear to have had the greatest influence in molding Whitehead's thought have been Plato, Descartes, and Leibniz, but this does not mean that he subscribes blindly to all their dicta. Being a man of independent thought he does not hesitate to point out wherein he disagrees with these thinkers.

The book is very inadequately indexed.



SCIENCE FOR THE CITIZEN. *A Self-Educator based on the Social Background of Scientific Discovery.*

By Lancelot Hogben. Illustrated by J. F. Horrabin. Alfred A. Knopf, New York. \$5.00. 9½ x 6½; xiii + 1082 + xix; 1938.

During the past few years a great many

books have appeared in which a single writer has attempted to cover the entire field of science. Many of these attempts have been disappointing but the present one is an exception. Because Hogben has attempted not so much to popularize science as to systematize it, he has accomplished both these ends. Not a little credit for his success is due to the 480 well-executed drawings by Horrabin.

A recent reviewer has criticized this book adversely because it contains no discussion of modern relativity physics. The student who already knows enough of relativity to realize how much he does not know is likely to feel disappointment at this omission, but the present writer feels that one might as well criticize Hogben for not having produced an Encyclopedia Britannica single handed. Perhaps later he will. Every treatise of this sort must omit much that some people will miss, in order to keep it within reasonable bounds, both as to bulk and cost. The student who assimilates all that this work contains about classical physics will be all the better prepared for relativity later.

The part of the book dealing with the biological sciences is not quite up to the standard of the rest of it, but again in any work some chapters are better than others. The ample index covers 18 pages.



VAN NOSTRAND'S SCIENTIFIC ENCYCLOPEDIA.

D. Van Nostrand Company, Inc., New York. \$10.00. 10½ x 7½; 1234; 1938. Over ten thousand scientific terms covering the fields of aeronautics, astronomy, botany, chemistry, engineering, geology, mathematics, medicine, mineralogy, navigation, physics, and zoology are explained concisely and interestingly by authorities on the respective subjects. Although a number of men in each field have contributed articles or acted in an advisory capacity, the responsibility for the treatment of each science has rested largely on a single person, thereby insuring greater unity than is usually possible when a great many persons contribute. The persons in charge of the items in the biological sci-

ences include Profs. A. W. Lindsey of Denison University, Hempstead Castle of Yale University, H. O. Elftman of Columbia University, R. S. Mueller of the College of Physicians and Surgeons, Columbia University, and R. M. Field of Princeton University.

Cross-references are indicated in the text by the use of bold-face type, thereby enabling the reader readily to find all the facts that bear on each topic included in the book. The topics are listed alphabetically, irrespective of the science. The print is good, the binding sturdy, and many illustrations are included.



BACKGROUND TO MODERN SCIENCE. *Ten Lectures at Cambridge arranged by the History of Science Committee 1936.*

Edited by Joseph Needham and Walter Pagel. The Macmillan Co., New York; The University Press, Cambridge. \$2.00. 8 x 5½; xii + 243; 1938.

This book is a reproduction of the inaugural course of lectures on the history of science presented at Cambridge in 1936. During the course, ten different eminent scientists gave accounts of the development of their particular fields of interest, and as a consequence, the volume is essentially a treatise on the foundation of modern scientific theories.

The early chapters by Cornford and Dampier deal with the development of scientific thought from the natural philosophy of the Greeks to the new conception of the cosmos by Copernicus and Galileo. The later chapters are concerned with the development during the past 40 years in the fields of physics, astronomy, physiology, biology, evolution and genetics.

An amazing amount of material is incorporated into each chapter, making the entire volume extremely meaty yet thoroughly readable and enjoyable. Every present-day biologist should steal enough time from his regular tasks to read *Background to Modern Science*.



THE POEMS OF RICHARD DE VEAUX.

Privately Printed, Baltimore, Maryland. 10 x 7; 82; 1938.

Richard De Veaux was the *nom de plume* of Mrs. Ethan Allen Andrews (born Sara Gwendolen Foulke). She achieved fame as a biologist in her own right through the remarkable study published in 1897 under the title *The Living Substance*. Shortly after her death Professor Andrews brought all her poems together in this beautiful volume for private distribution to friends. The poems cover a wide range of thought, feeling, and style. Some rise to heights of great and poignant beauty; others, and especially those written for her children, are completely charming in their light and graceful wit.

Altogether this volume seems the perfect memorial tribute to a remarkable woman.



COLOR PHOTOGRAPHY FOR BEGINNERS.

By Robert M. Fanstone. *Camera Craft Publishing Co., San Francisco.* \$1.50.

7½ x 4½; 136; 1938.

With careful use this little volume will undoubtedly lead the beginner in color photography to a satisfying amount of success in his fascinating hobby. The few books on the market which deal with the subject of color photography have been published more for the professional photographer than for the beginner, and for this reason there has been a real need for just the type of book here produced. The text contains a brief discussion on the principles of color photography, together with a presentation of the salient factors regarding apparatus, materials, and the processes of exposing, developing, and finishing the colored pictures.

The volume is rather sparsely, though beautifully, illustrated by a group of well-chosen polychrome photographs.

There is an appendix of Makers' Formulae and a complete index.



THE MODERN QUARTERLY. Volume 1, Number 2.

Lawrence and Wishart, London. 2s. 6d.

9½ x 6; 103-207; 1938.

A variety of subjects have found their way into this journal which sets itself to defending materialism and opposing reactionary tendencies, such as Fascism, which lead to "degeneration of thought and culture."

Among the articles is a study by J. B. S. Haldane on haemophilia in the royal families of Europe. It is interestingly and simply written, and would not only appeal to the lay reader, but at the same time give him a smattering of genetic knowledge. Another paper deals with the functions of literature and art as psychological propaganda for the creation of faith in national socialism, thus leading to deterioration of culture. Further articles present an evaluation of food consumption in Germany; a study of the history of writing and mathematical knowledge; and The creed of a dialectical materialist which is a verbose argument against use of the abstract and could well have been omitted.



THE SCIENTIST IN ACTION. A Scientific Study of His Methods.

By William H. George. *Emerson Books, New York.* \$3.00. 8½ x 5½; 354; 1938.

The American edition of this book, with the exception of the preface, is the same as the English edition which was reviewed in this journal in Volume 12, Number 2, page 245.



PROFILES IN HUMAN BIOLOGY. III AND IV

By RICHARD RICHARDSON

III

THE INFANTRY INSTRUCTOR

HE IS an officer and a gentleman,
But hardly a scholar.
It is most unfair
To smile at his uniform,

For there is a current tale
That it was designed
By some tailor at Whitehall
After a wild night at sea.

Should you tell him
That the medieval bowmen
Twisted their arrow points
To make wounds fester,
That negroes were inoculated with small
pox
In our Revolution
To carry disease to the enemy,
That we used pump-guns and bear-traps
With effectiveness
In the Late Unpleasantness,
Though indignantly protested
By the enemy,
He is bored.
For he is an officer and a gentleman—
Not a scholar.
And he does not seem to know
That the sole end of war
Is to win—
For defeat

Is suicide
And hence
Approaches mortal sin.
(A nice point
Made by
Saint Thomas Aquinas
Some seven centuries ago.)
He may have heard of Clausewitz and
Napoleon—
Successful men
Without any accepted Rules
Of combat or of honor:
For the sole end of war
Is to win.

If you ask him
His function
When in action,
He would probably reply
In the terms of the mythical cavalry officer
Of the late War:
"To give tone
To what otherwise would have been
A mere brawl."
He probably has not heard
Of the gallant captain
Of the "Alabama"
Who bitterly complained
Of Commander Winslow's
Vulgar action
In lacing his ship's sides
With anchor chains

To save his gun crews.
But he would approve the protest,
For he is a kindred spirit:
An officer and a gentleman—
Not a scholar.

He is always talking about
'The man with the bayonet,'
Not knowing
That Cumberland's artillery
Ended the Scot's wild charge
And hard cold steel
At bloody Culloden
In the '46's
Near two hundred years past,
Or that bayonet wounds
Were a curiosity
In the War between the States.

His idea
Of a good shot
Is one fair through the occiput
Requiring only
A hasty burial
As compared with
A shattered kneecap
That fills an enemy's bed
For months.

When next we fight
He will stand with his men,
Brave, cool, firm, erect,
An heroic figure
Until some sniper
Gets the range
And picks him off

At two thousand meters.
After brief but suitable
Obsequies
He will be replaced
By some realistic mechanic
From Akron,
Uncultured and ill-groomed,
Who shares
The blessed Saint Thomas'
Contention
That the sole end of war
Is to win.

IV

CLINICAL INVESTIGATOR: TYPE III

IT WAS written in the stars
That after the Shaman,
The Pontifex,
The Fili
And the Roundhead
Would come the Clinical Investigator:
Type III.
Not all of him
Nor many of him,
But a number sufficient
To tar-brush his betters.

He is an interesting person,
And to him
Comparison,
Computations
And Controls
Are equally odious.
He has never learned the difference
Between the verbs
'Is' and 'should.'
Like a hagiographer,
He considers it

Good form
To always add
A few extra miracles:
And his dice
Often throw
Double Sevens.

He blights
Whatever he may touch.
But he is uncurbed, for
"His strength
Is as the strength of ten

Because his heart is pure,"
And the Public
Still regards Santa Claus
As a Prominent Person
In medical circles.
We bear with him,
Knowing that
In due time
He too
Will depart
For the march-past
Of the honest but self-deceived
Is unending.

THE QUARTERLY REVIEW of BIOLOGY



ORGANISMS IN TIME

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"—that all living things are genetically related as members of one great family, one vast, living symplasm, which, though fragmented into individuals in space, is nevertheless absolutely continuous in time—"(W. M. Wheeler, *Social Life Among the Insects*, pp. 3-4.)

INTRODUCTION

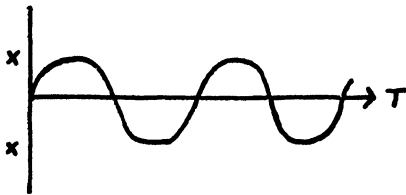
WITH considerable justification biology has been accused of lagging far behind the physical sciences in the formulation of broad principles serving to embrace the theoretical results attained from the detailed investigations of its many branches. It is usually argued in defense, of course, that the 'science of life' is not 'ready' for such a synthesis, but this defense has always borne the faint aroma of an alibi. So far there seem to have been few biologists who have indicated a very great willingness even to try. Most have persisted instead in grubbing away mole-fashion to build higher and higher the already mountainous mass of unorganized factual data, deriving ruminative pleasure from the size of the heap and having little concern about the truths that may be buried in its bowels. Now it isn't altogether my in-

tention to argue the question of the readiness of our science for a culling, nor do I intend to present any pet all-solving program or theory, but I do wish to draw attention to what impresses me as a promising lead that is being overlooked by biologists. I refer to a certain obvious and applicable concept, long since appreciated by our contemporaries in the physical sciences that we biologists for the most part have so far failed to incorporate in our own thinking—the concept of time.

It is most surprising how little attention has been paid to the significance of time by biologists. Here is a factor that has played an important part in the development of physical thought, and there is reason to believe its serious consideration would lead to consequences of equal importance in biology. Much of the tardiness on the part of biologists in thinking of organisms in terms of four dimensions seems to be based on a preconceived fear of the unknown or perhaps merely a stubborn literal adherence to Huxley's tenets of objective science. In any event the conception of the 'four dimensional continuum' which makes up a part of the

every day thinking processes of the physicist or mathematician is a mental stumbling block over which the biologist trips, and having tripped, despairs. Actually it requires no special kind of intellectual feat to think in terms of four dimensions; the task is only one of logically building upward from a basis of familiar spatial concepts. Such an approach might be somewhat along the lines of the following.

Space is known to us in three different conditions, linear, planal, and three-dimensional, which may be schematized by three straight lines converging at right angles to each other. Or to put it in more tangible form, motion may be limited to a line or a surface or have the whole of space at its disposal. As a crude example of the first possibility, imagine a train moving along a straight stretch of track. A skater gliding freely over the surface of an ice-rink would represent the second condition, and for the third, a bird flying in any direction in the air. For the purpose of analyzing each of these motions a little more in detail and in terms of precise physical conditions rather than by rough analogy, a simple case of linear motion is well demonstrated by a pendulum. If the distance the pendulum moves on each side of the middle position is X , then the continued motion of the pendulum is represented graphically, as a function of 'time', by a sine curve. What



we have here is a succession of linear displacements, X , along a second coordinate, T ; thus we see at a single moment, ad-

jacent in space, what in reality is a succession in time. In other words, motion in a single dimension appears as a two-dimensional picture. Exactly the same thing is true for the higher dimensions. Thus motion in a plane such as takes place uniformly in a circle about a vertical axis of T would be a screw line. The next step leads directly to the Einstein-Minkowski conception of all three-dimensional motion as a world line in four-dimensional space. But enough of that. Let us look at the problem from a little different point of view.

Imagine some sort of a creature whose conscious percepts are confined to planal space, just as ours are to three-space, and who has the same difficulty in conceiving of the third dimension as we do of the fourth. If this imaginary creature's consciousness could be compared to the surface of a volume of liquid, then any object that passes through the surface film from either above or below would be sensed as a plane. Suppose, for example, a block of wood marked off in colored squares were slowly lowered into the water, our flat-land creature would perceive a series of two-dimensional objects, each a distinct, separate entity of a characteristic color. Yet we, with our superior powers, know the individual colored squares to be merely parts of a three-dimensional whole. How is Mr. Flat-land to know this? Only by assembling the parts into a whole in his own consciousness. In other words, the sensing of this new third dimension to him would consist of the perception of an organized heterogeneity which takes the form of a succession of two-dimensional objects passing in review from the 'future' above the liquid surface through the 'present' of the surface itself into the 'past' below. 'Time' to Mr. Flat-land is our third dimension.

The step upward to a conception of four-space can perhaps be made now with less difficulty, for just as two-space forms are but the boundaries of three-space bodies, so also may three-space forms be regarded as abstractions from four-dimensional bodies.

Now it must immediately be emphasized that time is not to be considered as only another dimension or direction in space. Such a notion is absolutely erroneous, for it is impossible to imagine a new dimension super-imposed upon an already three-dimensional space. The futile attempt to do so represents, I suspect, the secret of the difficulty in which many individuals find themselves when they consider this problem. The thing to be appreciated is that the *fourth dimension only represents the existence of the other three*. This statement requires some amplification.

To speak of the existence of an object is only to express the certitude of finding the object as observed at the moment similar to itself after a given interval, no matter how short that interval. Expressed in a slightly different manner, existence itself implies duration; time becomes the essence of existence, the very condition of the existence of the three dimensions of space. It is not only wrong, then, to conceive of time as an additional dimension in space, but equally wrong to try to compare time and space, for as du Nouy has said, "space has no significance outside of time". One is manifested by and in the other. An example from theoretical physics will perhaps illustrate this more clearly.

Imagine an atom consisting of a central nucleus with a single electron rotating around it. Time will be required for the electron to make the circuit. If, now, one should shorten the history of the atom to a period of time briefer than that required for one rotation of the electron, then

clearly the atom has not even been permitted to manifest itself. It will be completely non-existent below the level of a given minimum of time, the minimum required for the rotation of the electron. The atom can exist as a definitive object only in terms of time. *A material object cannot exist instantaneously.*

This somewhat subtle concept of the fusion of time and space generates numerous implications, many of which have been discussed and developed by writers such as Bergson, Pearson, Jeans, Minowski, and most recently, du Nouy. Many of these implications, however, have no direct bearing on the problem of biology and may be passed over without further reference.

BIOLOGICAL TIME

Proceeding to the question of how this 'time factor' is applied in conjunction with living organisms, we are immediately brought face to face with the almost insurmountable difficulty of attempting to describe or define what we mean by a living organism. Analyzed chemically and physically, organisms reveal no characteristics serving to distinguish them from non-living entities. They are something more than static, three-dimensional objects differentiated by some structural peculiarity or featuring a particular kind of chemical make-up. Such physical and chemical heteronomy is simply not found. We know living things not by how they are built, but by *what they do*. The materials comprising an organism are engaged in a multitude of activities, all directed towards the maintenance of both the individual and the tribe to which it belongs. How these separate activities are integrated into an organized whole is a problem in itself not to be considered here. Rather, the point to be made is that living things are truly organized

events, and events manifest themselves only in time.

To illustrate this further—even in the time required for the writing of this sentence I have become considerably modified as the result of a multitude of physicochemical reactions. The force required to push my pencil across the page has necessitated the expenditure of a certain amount of energy with a corresponding consumption of oxygen and release of carbon dioxide. The associated mental activity has likewise taken its toll of energy; all this in addition to the many reactions concerned merely with the normal maintenance of the body. The heart has continued its regular beat, some blood cells have reached the end of their life span, and others have been born, kidney tubules have removed a bit of waste from the blood, the pancreas has released a volume of digestive fluid and is in the process of manufacturing more, and so on. In the space of a minute or so I have become a changed man. What is any organism other than such a steady stream of physiological activity, a complex of physicochemical reactions in the form of an object that we have all agreed to call a cat or an amoeba or a rose-bush, depending upon the form taken?

Suppose you are sitting here in the room with me as I write. Now and then you look up from the magazine you are reading and note that I am still scribbling away. For an hour or more you are present, and, let us say, in that space of time you look up and observe me half a dozen times and are totally unaware of my presence between times (it's a first rate detective story you are engrossed in). Actually, of course, I have been present all the time, even though you have observed me only at intervals. In other words, your six observations of my existence have been only six cross-sectional intervals totalling

no more than a few seconds taken out at random from a continuous existence of an hour. This is a crudely designed situation, but it serves to illustrate a somewhat subtler conception that must be appreciated.

An organism, we have said, is a constantly changing system, presenting at any one instant a physicochemical makeup distinctly different from that of the instant before. When we speak, then, of the organism as an entity, do we have in mind the system as we see it at this particular moment, the moment preceding, or the moment to follow? Obviously at no one of these. Our impression of what we observe at one instant is conditioned by memory of that of the preceding instant and it in turn is carried into the instant following. The pictures overlap or blur, so to speak, and out of the blurring we formulate the whole. The oft-used analogy of the motion picture still serves as the best illustration of this. The series of isolated 'still' pictures printed on the film are projected so rapidly as to create by the overlapping of their impressions upon the retina the illusion of motion. In the same fashion the mere act of observing an organism occupies an interval of time; existence itself, as stated earlier, implies time, i. e. it is impossible to think of something as existing instantaneously. Living things are clearly four dimensional, even more obviously so than non-living things. This static spatial entity that our minds persist in conjuring is nothing more than a three-dimensional abstraction, a cross section as it were, from a four-dimensional whole.

Let us develop the conception a little further. So far we have spoken in terms of a limited number of successive cross sectional pictures over a brief period of time. Yet exactly the same thing holds for longer intervals, in fact for the entire

life span of a given organism. We customarily date the beginning of a new individual from the moment it begins to carry on a relatively independent existence, i. e. from the time it buds off the parent or is born or hatched, and the end with its death. This interval will vary from a few hours to many years, depending upon the organism. Choose man himself. John Doe as a two-year-old infant and a thirty-year-old man are cross sections abstracted from the four-dimensional whole in precisely the same sense as are successive observations of the adult John Doe made over the space of a few moments. True enough the interval of time between cross sections is measured in the first instance in years and in the other in seconds, but this is a difference of degree only and is not significant. The thing is, our sensory equipment is such that we perceive an organism objectively as a succession of cross-sectional pictures which together and only together comprise the whole. (We are not much better off than Mr. Flat-land!) John Doe on the morning of his second birthday is no more and no less the real John Doe than at half past five on the evening of his thirtieth birthday. The true John Doe—the real organism—is that ever changing, nonstatic totality, that stream of physico-chemical reactions manifesting itself in changing three spatial form that persists from birth until death.

One may well immediately ask why limit the organism to the hyper-dimensional entity existing between birth and death. The answer to that is, no reason at all; in fact there's every reason for not doing so. The biologist knows full well that the phenomenon of birth (or any corresponding phenomenon such as hatching) is only an incidental event primarily marking the transition of an organism from a dependent to a relatively independ-

ent existence without interruption of the ontogenetic process itself. The marsupials illustrate this particularly well.

The opossum embryo, for example, is born in a very incomplete structural condition after a gestation period of a mere thirteen days and thence continues its development for another 50 days or so in the marsupium. Birth of any eutherian mammal at a corresponding stage of development would certainly be considered as being decidedly premature. The 'incidental event' in the case of the marsupials just happens to occur earlier in embryonic life, or shall we say that the site of development is simply shifted from uterus to marsupium. The point is, parturition does not mark the end of one kind of an individual and the beginning of another; as an event it may be shifted before or backwards without significant influence upon the flowing stream of form change. The foetus an hour or a day before birth is thus truly as much a part of the real, complete individual as is the newborn of an hour or a day. Actually there is much less difference between them, i. e. the cross sections are closer together, than between the infant and the man of thirty. The true, whole organism, then, must include all of its embryonic life as well—the anterior boundary of the four-dimensional individual must be pushed forward to the condition of its origin, that is, to the single-celled impregnate ovum. The one conspicuous difference would be found in the much greater rapidity of form change during embryonic life, which of course is only an expression of the greater rapidity with which morphogenetic events proceed and succeed each other.

THE ORGANISMAL CONCEPT

So far in our discussion, we have assumed a very comprehensive view of

living things, looking upon any stage of an organism's ontogenetic or adult history as only a part abstracted from a hyper-dimensional whole. Sight must not be lost of the fact, however, that such abstracted parts are of themselves also wholes, albeit wholes of a lower order. Any cross section that one might choose, whether it be a twenty-five somite embryo or thirty-year-old adult, is also a unit, an organized, integrated going concern, it itself made up of parts subsidiary to the whole which in turn is a part of a greater whole. Thus an individual of any historical stage may be analyzed progressively downward into systems, organs, tissues, cells, and cell components which, although they exhibit a certain degree of ontogenetic and adult independence, are entities of a lower order than the whole and bent essentially upon the service of the whole.

In this connection attention should be drawn to the logistic system developed by Woodger (1930) in a study of the relation between embryology and genetics. Woodger conceives of the organism as a system of separate entities, ranging from the lowest cell component to the complete individual, arranged in hierarchial order. Every part is a whole, in a sense, but each is only a part of the whole of the systemic level above it and includes the whole of the level below it. To illustrate, the endoderm of a gastrula is a whole of one level, but only a part of a greater whole, the gastrula itself. Likewise the cells making up the endoderm are parts of the part of the whole, the nucleus of one such cell a part of the part of the part of the whole and so on. Woodger also conceives of a greater whole, the "division hierarchy" which includes the entire ontogenetic history of the organism. A given embryonic stage of development, therefore, becomes a 'short temporal slice' of the division hierarchy. Though clothed in logistic language, Woodger's notions would seem to be essentially comparable to my own.

The analysis of organisms in terms of their parts has long since been carried out with remarkable thoroughness. The structure of organs and systems down to

their very minutia is known to us and the manner in which they perform their individual functions is known almost equally well. To the pure mechanist a complete knowledge of the workings of its various parts is all that is necessary to describe the nature and activities of living things. But there has always been the lurking suspicion that an organism is something more than the mere sum total of its individual parts—a suspicion crystallized in times past in the form of various vitalistic interpretations and more recently in conceptions that may collectively be described as organismal. Stripped of the variable trappings with which it has been adorned by many interpreters, the organismal point of view is simply one of recognizing that life is not a property of any particular kind of substance or structure, no matter how complex, but of an *organization* and that this organization is invariably manifested as an organism. There is no life except in this form. We may talk to the freshman of 'living substance', but nobody ever saw protoplasm running around loose. The idea of living substance as distinct from an individual organism is a pure abstraction that has no counterpart in nature. Organisms thus become the fundamental unit of biology and the examination of any of the phenomena that we associate with living things must invariably be made in terms of this unit.

We may well marvel at the beautiful functional integration of the organs and systems making up the multicellular organism and yet have no comprehension of the fundamental unity involved. For that integration is not solely one such as we observe in a smoothly working machine, but rather one wherein all parts are devoted entirely to the benefit and maintenance of the whole. No one knows this better than the physiologist who has

learned that a complete understanding of the working of one part is to be had only in the light of its relations to all other parts. Similarly the psychologist, who is coming to appreciate that the proper interpretation of behavior can be made only in terms of the organism as a unit.

The individual performs not only as a functional unity, but under any and all conditions attempts to maintain as far as possible that essential unity. Witness the phenomenon of regeneration wherein the whole is reconstituted from a remaining part, often a very small part. The thought of regeneration incites the further realization that the activities of the organism are as equally related to the ends of development and reproduction as they are to its every-day performance and maintenance. The essential wholeness of living things is no more clearly marked than during ontogeny.

It has already been emphasized that any embryonic stage is as truly a segment of the real organism as is any post-natal stage, the period of ontogenetic life differing from later periods only in the greater speed of flow of the stream of morphogenesis. It is this very rapidity of form change that brings the underlying wholeness into sharp relief, and it has been the function of the experimental embryologist to take preliminary steps in its analysis. The data from embryology have been assembled in support of the organismal hypothesis by so many writers (cf. reviews of the material by Bertalanffy, Woodger, and Russell) that it will suffice to marshal only a few of the more general experimentally derived conclusions for the purpose of illustration.

The ability of a mutilated organism to reconstitute the lost parts has already been cited. An analogous situation is found wherein a fragment of a germ, e. g. a half-blastomere, produces out of its own

substance parts to which it normally would not have given rise, or otherwise regulates itself so as to produce the whole. Induction phenomena in general likewise emphasize the wholeness of embryonic germs. This is particularly conspicuous in the formation of secondary embryos whose materials are derived partly from the inductor itself and partly out of the surrounding materials. And finally there is that excellent demonstration lodged in the axiom that the development of the part is a function of its situation in the whole which has been an outgrowth of the concept of the embryonic field.

This extremely brief treatment of the organismal point of view has been introduced solely to further emphasize the essential oneness of the individual from egg through adult. But the fertilized ovum actually represents an anterior limit as arbitrary in definition as the newborn infant. The events of fertilization rightly belong in the history of the individual, and pushing still further along, the ovum itself has a complex maturation history which in many forms may actually overlap the initial stages of specific embryonic development. So the boundary is once more moved forward, this time so as to include in the scope of the hyperdimensional individual all of the maturation history of the egg-cell. There you may be willing to establish an anterior space-time limit, but pause momentarily and consider at this point one of biology's best established tenets, the principle of the continuity of life.

THE CONTINUITY OF LIFE

So far as we know life is not being created *de novo* at the present time. Rather, since its inception on the earth's surface no organism has ever arisen save from some preexisting organism, a con-

tinuum no more vividly described than in the eighty-year-old words of Virchow:

"Where a cell exists there must have been a pre-existing cell, just as the animal arises only from an animal and the plant only from a plant. The principle is thus established—that throughout the whole series of living forms, whether entire animal or plant organisms, or their component parts, there rules an eternal law of continuous development." (*Cellular Pathologia*, 1858, p. 25.)

It matters little whether this continuity be maintained by direct fission, as in the case of some of the protozoa, or by more complex means involving the setting aside and transmission of definitive germ plasm. The thing is, the individual as an ovum is inviolably linked with its progenitors and thus represents the initial stage in a *new cycle of the hyperspatial individual* rather than the beginning of an entirely new entity. It follows, then, that these self-same progenitors must be included as an integral part of the whole and their progenitors in turn, and so on right back to the very beginning of life. From such a point of view an individual's phylogenetic history is as truly a part of the real organism as its ontogenetic history. Essentially this same idea lies in the words of Russell (1930, p. 171) who says:

The living thing at any one moment of its history must be regarded as merely a phase of a life-cycle. It is the whole cycle that is the life of the individual, and this cycle is indissolubly linked with previous life cycles—those of its ancestors right back to the dawn of life. This is what we mean by the continuity of life. And the activities of the organism at any stage of its career can be understood only if they are reintegrated in the individual and evolutionary life cycles.

Just how it happens that since the beginning of life new life cycles have exhibited change and divergence in many directions is the problem of evolution itself, and in conjunction with this some of the conclusions derived by Professor A. C.

Kinsey from his studies on parasitic Hymenoptera are of interest.

RECAPITULATION AND PHYLOGENY

Kinsey contends that the classic conception of evolution as having progressed by dichotomous branchings from common stems as pictured by phylogenetic trees is fundamentally false. As the fossil connecting links between taxonomic groups are uncovered and the similarities and relationships of present day species are further analyzed, the phylogenetic picture becomes one of continuous chains of species of which only the diverse ends, so to speak, represent higher categories. Descent, therefore, has been linear rather than dichotomous and the higher taxonomic categories are only

"arbitrarily delimited sections of phylogenetically continuous chains of species." (Kinsey, 1937, p. 219.) "The same system of genetics which explains Mendelian races and the origin of species will explain the nature and origin of any higher category, for there are no characters in such categories apart from the characters of the species of which the group is composed. Evolution is never more than a process of change in single genes, rearrangement of gene complexes and aggregations of genes, and the modification of gene frequencies in the development of specific populations." (*op. cit.*, p. 222.)

In these chains there are no real discontinuities, only apparent ones due either to lack of taxonomic data or actual extermination of once existent forms. One can conceive how, if data concerning all organisms past and present were available, they would all assume their correct positions or levels in the phylogenetic succession. Kinsey himself points out that the validity of this interpretation, based as it is on a limited group of insects, can be established only following studies upon a great variety of forms. In any event, his conclusions suggest interesting possibilities.

Is it too far fetched, for example, to

look upon that collection of individuals, which in their variety comprise the species, as an abstraction from the whole, albeit a more comprehensive one, in the same sense that one individual or ontogenetic stage thereof is a cross section of a more limited sort? The individual, the species, the genus, all other taxonomic categories are thus only abstractions of variable degrees, i. e. of successive levels of comprehensiveness. Out of this there can come only one conclusion: all living things, plant and animal, comprise a continuum that is *the organism*. There is only *one organism* and it manifests itself in a multiplicity and succession of forms and complexities. The phylum or the species has no more fundamental significance than has a three-day-old chick embryo or Harrison's 'Stage 23' of *Amblystoma* abstracted from the whole. The phylum and the embryo are merely levels of a different order or degree; or shall we say, subsidiary organisms selected at two extremes from the hierarchy of gradating morphological levels which comprise the whole—*the hierarchy which is the organism*.

It is of great interest to observe how such an historical point of view may further an understanding and to some extent give an answer to the problems of recapitulation and heredity. Briefly, the form and activity of an organism at any one time, i. e. any temporal slice, is related both to its past and to its future. Recapitulatory structures need not be explained on a basis of the past somehow having made a permanent imprint upon the future, nor by any variety of mnemonic theory; paeligenetic characters, so-called, may very well be those featuring the anatomy of the individual at that particular cross-sectional stage of its life cycle, to be compared with those characters designated as coenogenetic in the same manner and sense that the general verte-

brate features of an adult mammal are to be compared with those which are purely mammalian in character. An organism inherits its form and structure and passes it on to its descendants because its past and future, as well as its present, *are the organism*.

To illustrate with a specific example, take the excretory system which is so commonly employed as a demonstration of the remarkable parallel existing between ontogeny and phylogeny. Every sophomore in zoology can rattle off in the very best parrot-fashion the ontogenetic succession of kidney types and make the usual phylogenetic inferences. Now although all morphologists have not been and are not now in complete agreement, a prevalent opinion holds the pro-, meso-, and metanephros to be merely parts of a single, continuous organ which develop in temporal order from anterior to posterior. Without going into all the morphological evidence, it may be pointed out in favor of this conception that in both their development and final structure there is far less distinction between the three kidneys than appears at first glance.

Comparing the pronephros with the mesonephros, where perhaps the essential relation they bear to each other is less obvious, one finds first of all that the tubules of both organs develop in fundamentally the same fashion from the nephrotomes. Furthermore, the structural characters usually serving to distinguish the type tubules of one from the other are so vaguely defined, or shall we say mutually distributed between the two, in the case of such forms as *Lepidosteus* and *Hypogeophis* that the distinction breaks down entirely. And in the Myxinioids, e.g. *Bdellostoma*, and less clearly in *Petromyzon* and some Amphibia, the history of the tubules shows them without

question to be serially homologous. In addition, the longitudinal drainage duct is here derived throughout its length from the outer ends of the tubules, all of which points further to the general conclusion that fundamentally the pro- and mesonephros represent two portions of an originally continuous and uniform archinephros with an archinephric duct. The general tendency in the higher craniates for the pronephros to precede the mesonephros in both time and space is a secondary acquisition which should not be allowed to obscure the fundamental oneness that now manifests itself in time.

In both structure and development the mesonephros and metanephros are even more alike. The history of the mesonephros itself is indicative of this. Its anterior regions, for example, show a progressive reduction (and assumption of reproductive functions) with a corresponding shift of excretory functions posteriorly. Even in Amphibia and Pisces it is the posterior part of the organ that plays the major excretory rôle. In fact in the Selachii and Teleostei there is a pronounced tendency for the openings of the tubules to shift backwards and combine to form almost a separate organ with a special duct of its own opening at the base of the mesonephric duct proper. This tendency is so marked as to lead some workers to homologize these elements with a metanephros and ureter. It would seem better, however, to employ Kerr's term 'opisthonephros' for such a setup. In any event, the ontogeny of the definitive metanephros of the amniotes shows it to be a structure not essentially different than its precursor in the anamniotes. Meso- and metanephros become in fact merely parts of a single structure manifesting themselves ontogenetically in amniotes at different temporal levels.

Certain experimental evidence is also

suggestive of the oneness of the temporally partitioned excretory system. Recently Waddington (1938) has shown that if the posterior elongation of the Wolffian duct of the chick embryo towards the cloaca is mechanically checked, the mesonephros does not properly develop, appearing only as small patches of non-tubular tissue. These results confirm an earlier suggestion by Needham (1931) that an organ which is vestigial in the sense that it has lost its physiological function may be retained because it provides a morphogenetic stimulus which induces the formation of a later evolved structure. This is actually only a restatement of an idea long since introduced by Kleinenberg (1886) than the new can arise only in an organism containing the old, i.e. that it is dependent on the prior existence of the replaced organ. Keeping in mind that the expressions 'new' or 'later evolved' refer only to relatively recent modifications of previously existing structures, we are led directly back to an earlier conclusion that because we are dealing with a continuum, vestigial or recapitulatory structures occur because they comprise a part of the whole and determine its character just as truly as do the final products.

Any other organ or system of organs one might choose seems to be amenable to an interpretation of the same sort. The reduction and modifications of the aortic arches; the phylogenetic and ontogenetic transformation of a pulsating tube progressively into a two-, three-, and four-chambered heart; the progressive erection of the superstructure of the brain upon a fundamental four-ventricle, five-vesicle foundation; the origin and relations of the pharyngeal pouches and arches—these and all others are subject to the same interpretation. The lower levels of development are in both phylogeny and ontogeny earlier temporal slices from the whole, and thus

at the same time the precursors of the higher levels or later temporal slices. So it results that a general parallelism between ontogeny and phylogeny occurs, although this is far from 'recapitulation' in the original literal sense of the word. To paraphrase an earlier statement, a structure in its development presents a form reminiscent of its phylogenetic past because its past (and future) as well as its present *are* the structure.

COMPARATIVE BIOCHEMISTRY

Though from an entirely different point of view, much the same picture of oneness and continuity is obtained from the assembling of the facts of comparative biochemistry. Look first of all at that spatial hierarchy consisting of systems, organs, tissues, cells, and so on down which comprise the individual at any single stage of its history. The inorganic constituents, i.e. the lowest level of organization of the cells, will show a remarkable similarity of composition, suggesting the existence of a determinate ground-plan upon which all living cells are based. At the next higher level, that of small organic molecules, the similarity of chemical composition is still great though some variety now becomes manifest. At the still higher level of the enzymes, the divergence is greater, though close resemblances can still be traced as evidenced by the wide distribution of similar enzymes among not only different tissues but even different individuals. (Witness also the extensive distribution of essentially similar endocrine substances through the whole range of animal forms.) Though the essential biochemical continuity between the higher levels of organization, i.e. the tissues and organs, and the lower is less obvious, yet Needham (1936) has gone far toward marshalling the data supporting the reality of this

continuity as well. Acceptance of this opens the door to an interpretation of morphogenesis as a manifestation of change in biochemical configuration. Starting with a fundamental ground plan at the lowest levels of the spatial hierarchy, all subsequent modifications expressed by changes of outward form are both limited and directed to definite pathways, for any conditions that exist at one level must be compatible with and are determined by those conditions at the preexisting level and they in turn determine and limit the conditions at the next higher level. Herein undoubtedly lies the secret of the nature of that whole collection of ontogenetic associations comprising organizer phenomena.

Still less obvious than the chemical continuity of the parts within the individual is that existing between individuals and between taxonomic categories, yet there is evidence of continuity here too. Briefly, we have the comparative series of growth curves obtained by Huxley (1932) which suggest a common plan of animal growth which is, after all, only an expression of community of physico-chemical processes. Then there are the long known striking resemblances between the ionic compositions of the blood and tissue fluids of widely different animals. And finally there is that system of interlinked metabolic processes known collectively as the Parnas cycle which has been demonstrated to prevail widely in the muscles of both vertebrates and invertebrates.

True enough only by a considerable extension of such facts of comparative biochemistry can the relations of the various levels of the organismal hierarchy be clearly established, but even this limited information points suggestively to the same principle of continuity already established on morphological grounds. But

to turn to still another aspect of the picture.

Earlier in this discussion it was pointed out how difficult it is to distinguish between the living and the non-living. So long as we are dealing with objects obviously alive like dogs and cats in contrast to objects obviously inanimate such as rocks and water, there is no confusing them, but many entities occupy an intermediate position and are not amenable to pigeon-holing. In fact much fruitless labor has been expended by those who would do so, for they at the same time arbitrarily establish a boundary between the living and the non-living which does not exist.

The imperceptible transition of the one into the other can be appreciated in no better way than by considering how well nigh impossible it is to characterize in precise terms even those things which we know to be alive. All of the qualities that we associate with life, i.e. irritability, metabolism, growth and reproduction, etc., are not invariably manifested by living systems, and conversely any one or several together of these properties may be exhibited by systems which are unquestionably non-living. Comes then the full realization that living things are not featured by any substance, structure, or activity peculiar and exclusive to themselves, but share their properties with the inanimate.

With life thus defying precise definition, as it does, it matters little how we characterize those entities occupying the transitional position between the strictly living and the strictly non-living. The entities in mind are those lying below the limits of microscopic visibility in that 'world of neglected dimensions' between the coarser constituents of cell structure and the molecular structure investigated by the chemist. Such are those disease

producing agents known as the filterable viruses and possibly also the bacteriophages. Biologists have long suspected that these agents, exhibiting as they do properties of both the animate and inanimate, represent the connecting link between the two. Evidence amounting almost to verification of this suspicion has recently come in Stanley's successful isolation of a crystalline protein possessing the properties of the tobacco mosaic virus, so it now appears valid to say there truly is no break between the living and the non-living. The one grades imperceptibly into the other.

WHITEHEAD'S PHILOSOPHY OF ORGANISM

The next and final step is that one already taken by Professor A. N. Whitehead. Professor Whitehead has developed a philosophy of organism in a series of important books, notably *Science and the Modern World*, and *Process and Reality*, and these works in turn have been the object of numerous reviews and commentaries, (cf. Agar, 1936 and Emmet, 1932) to all of which one should turn for the argument supporting the following concluding generalizations. This generalized picture of Whitehead's system will at the same time serve as a concluding restatement of the point of view developed in the preceding pages.

Fundamental to an understanding of Whitehead's system is his concept of reality as consisting of process of experience rather than substance. The essence of a thing is not what it is, but what it does, and the doing of something implies an interval of time in which to do it. Now real things are in the main extremely complex and thus are subject to analysis or subdivision, which is to say they are reducible to a collection of ultimate processes. Any one such ultimate process, if it is incapable of further subdivision,

comprises an actual entity. Conversely, then, the final real things of which the universe is composed are actual entities. Just what these ultimate processes are, electronic vibrations or something even simpler, is not important for our purposes. What is important, however, is that reality consists not of substance exhibiting or supporting certain qualities, but is rather an event in experience expressing itself in 'subjective form'.

An actual entity furthermore is not to be conceived of as an isolated, unrelated unit, for it bears a close relation to its contiguous predecessors and in turn influences its successors. In other words, the character (subjective form) of a given entity is determined by its reception into its own constitution (prehension) of the qualities (initial data) of its precursors and it in turn transmits itself to the future.

The general scheme of relatedness by way of which the prehensions of actual entities are bound into a group Whitehead calls the *extensive continuum*, whose most obvious feature is its space-time character. Such a continuum of entities in "the unity of the relatedness constituted by their prehensions of each other" (*Process and Reality*, p. 32) comprises a nexus. The simplest type of nexus consists of a temporal succession or 'strand' of actual entities in the same sense that ontogeny consists of a succession of morphological 'time-slabs.' A nexus, too, is a unity in itself with properties peculiar to itself. This conception of unity for the first time strikes a responsive chord in the minds of biologists, for in it is found the nucleus of the idea underlying

all organismal theories, namely that the whole is more than the sum of its parts.

Now it must be appreciated that the simplest nexus is still below the grade of an atom; that actually an atom consists of many strands, i.e. electrons and protons. Atoms in turn are brought together in the form of molecules, the molecules into compounds, and so on through to the most highly evolved living organism. Each higher level of organization is likewise designated as a nexus. In other words, there are many types or degrees of nexūs and, most important, each includes all the nexūs below it. (Cf. Woodger's "division hierarchy.") This does not mean, however, that the character of a nexus of relatively high order consists only of the sum of the characters of those nexūs it prehends. Subjectively there is multiplicity; objectively there is unity and individuality. Thus the gradating nexūs take the form progressively of "electrons, molecules, rocks, and men," each an objective unity but each, too, a part of the whole space-time continuum, *the ultimate nexus which is the universe*.

It is the universe, then, that is *the* organism, and all the nexūs prehended by it are organisms of a gradating subsidiary character. Atoms as well as men are organisms, the one a nexus of a low order and non-living, the other of a high order and living. The difference between living and non-living organisms thus is one of degree only and we can join Whitehead in saying that "Biology is the study of the larger organisms, whereas Physics is the study of the smaller organisms" (*Science and the Modern World*, p. 145).

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EFFECTS OF FEEDING THYROID SUBSTANCE

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PHYSIOLOGICAL ACTIVITY AND CHEMISTRY OF THE THYROID GLAND

ACCORDING to Galen (translation by Daremberg, 1854) all the writers up to his time, including Hippocrates and Plato, described the thyroid body together with the salivary and thymus glands as lubricators of the pharynx, larynx, and trachea. The spongy constitution of these bodies, together with the fact that the upper end of the larynx is entirely closed by the epiglottis while swallowing (thus keeping out all but a very small quantity of liquid) seemed to Galen to be contradictory to the time-honored lubricating function of these glands. The spongy nature of the glands seemed better suited for absorbing purposes than for producing lubricating substances. Then, too, it was puzzling to Galen that if these glands had been created for lubricating the larynx, their product was prevented from entering the very organ it was intended to lubricate.

The thyroid gland was carefully observed by Vesalius (in Ball, 1910), a fact which is attested by its presence in his excellent anatomical drawings. Like many other organs, however, (e.g. the vermiform appendix) it apparently did not seem important enough to receive any discussion as to its function.

So the thyroid was an object of both speculation and controversy, as well as of negative interest, until 1656 when it

received its first reasonably accurate description by Thomas Wharton in his *Adenographia*. Wharton's reputation as an anatomist rests principally on his *Adenographia*, the first treatise devoted to a comparative discussion of the glands of the body. Born in 1614, the son of a land owner, Wharton took the degree of doctor of medicine at Oxford, and then practised his profession in London. He was appointed physician to St. Thomas's Hospital in 1659, and was for many years an active and highly esteemed member of the College of Physicians. He died in 1673. In his book, Wharton attempts to explain the term 'gland' and takes the position that secretion is a gland's primary purpose. He gives very detailed descriptions of the anatomy of the glands of the body, and assigns to each of them a group of general functions in the physiology of the organism. The thyroid is described in detail, particular note being made of its great vascularity. The functions of the thyroid, according to Wharton, were (1) to heat the hyoid cartilage which would normally be cold; (2) to lubricate the larynx; and (3) to give rotundity and beauty to the neck. It seems strange that even though Galen, fifteen centuries before, had pointed out the difficulties encountered in explaining the lubricating function of the thyroid, Wharton still held to that view. Today these functions seem fantastic, but with minor variations they were regarded as the essential ones

until Claude Bernard's recognition of internal secretion as opposed to external secretion (1855) shed new light on the true physiological activity of the thyroid gland. It was he who first (1859) recognized and described the thyroid as one of the glands of internal secretion.

The physiologists gleaned much understanding of the thyroid from the physicians whose clinical observations on the pathology of the gland led to more exact knowledge of its functions. Parry (1755-1822) in 1786 left an account of exophthalmic goitre which is so complete and original that it more justly entitles him to the honor of its discovery than either Graves (1835) or Basedow (1840). He said (1825, ii, p. 112):

"... a lump the size of a walnut was perceived on the right side of her neck. This continued to enlarge till ... it occupied both sides of her neck, so as to have reached an enormous size, projecting forwards before the margin of the lower jaw. The part swelled was the thyroid gland. The carotid arteries on each side were greatly distended; the eyes were protuded from their sockets, and the countenance exhibited an appearance of agitation and distress, especially on any muscular exertion, which I have rarely seen equalled. [These observations suggested to Parry (*loc. cit.*, p. 128)]: ... that the thyroid gland, of which no use whatever has hitherto been hinted at by physiologists, is intended in part to serve as a diverticulum in order to avert from the brain a part of the blood, which, urged with too great force by various causes might disorder and destroy the functions of that important organ."

In 1835 Graves gave such an admirable description of exophthalmic goitre that the disease still goes by his name. The description was similar to that of Parry in that the thyroid was enlarged, the heart rate was increased, the face was marked with anxiety and hysteria, and the eyes protruded to such an extent that the lids could not be closed.

The next important treatise on exophthalmic goitre came from Basedow (1840) and it was he who gave the three

basic symptoms of the disease, or the *Merseburg Triad*: (1) The enlarged thyroid gland; (2) exophthalmos; and (3) tachycardia.

Shortly after the above observations were made on exophthalmic goitre, several physicians reported a group of symptoms associated with the wasting or absence of the thyroid body. Thus, Curling (1850) was the first to associate cretinism with the absence of the thyroid body. Two cases were cited where the thyroid gland was absent and each case presented characteristics typical of cretinism—the stunted yet plump body, the idiotic expression, the broad face and thick lips and tongue. Fagge (1871) suggested that sporadic cretinism is different from endemic cretinism in that it is not associated with goitre, but rather with a wasting or absence of the thyroid. The histories of Fagge's cases showed a general stunted growth, round head, broad face, thick lips, broad hands and feet, and a deficiency of mental powers. Gull (1874) was the first to call attention to cretinism in adults. This report was based on the observations of five cases of adult cretinism. In all of them the author noticed that the patient became more and more languid, with a general increase in bulk. The face became full and round, the complexion soft and fair, and the tissues under the eyes became loose and folded. The lips became large and purple, the hair flaxen and soft, the whole expression placid, and the hands broad and spade-like. There was much fat over the body and in several cases there were traces of oedema. In these cases the author said the condition was not due to any malady of the internal viscera. He stated that he did not know the exact state of the thyroid gland, though it was evident that it was not enlarged. Ord (1878) described five more cases of adult cretin-

ism, and proposed the term *myxoedema* for the malady. In all cases the thyroid gland was diminished and the characteristics were similar to those noted by Gull. The accompanying oedema in most cases suggested to Ord the term *myxoedema*, though he had no idea of its cause.

Progress in knowledge of the pathology of the gland received impetus as a result of surgical intervention. The mysterious importance of the thyroid gland was emphasized by Schiff (1856) when the gland was excised with fatal results in the dog. Death did not always occur immediately after complete extirpation, but the animals grew more and more languid, and finally, in many cases, died in tetany.

Kocher was the first to excise the thyroid for goitre (1878) and performed this difficult operation over 2000 times with only 4½ per cent mortality. Later (1883) he published his description of "cachexia strumipriva" which he had found as a sequel to 30 out of his first 100 thyroidectomies. This work, in connection with the pioneer experiments of Schiff and the Reverdins, really inaugurated the physiology and physiological surgery of the ductless glands. Reverdin and Reverdin (1883) found that two or three months after complete ablation of the thyroid, their patients presented characteristics analogous to those of cretins; a condition which they termed "operative myxoedema." These investigators did not have 100 per cent mortality, even when the entire gland was removed. In the light of present knowledge, one realizes that this was possible because, as one of the authors stated, the thyroid membrane was left intact by his new method of operating (hence leaving the parathyroids of which he knew nothing). Death from tetany resulting from complete ex-

tirpation of the thyroid in animals seemed to indicate to Schiff (1884) that the thyroid had an important rôle in the nutrition of the central nervous system.

In 1884 Horsley (in Paget, 1919) produced myxoedema in monkeys by excising the thyroid gland. The phenomena which followed thyroidectomy in monkeys were similar to those noted by Schiff working with dogs, and to the Reverdins' 'operative myxoedema.' The reactions of the animals were listed in detail, each factor being compared with a similar factor in myxoedema in man. Thus, the conclusion was reached that myxoedema was practically the same disease as sporadic cretinism; probably identical with Kocher's 'cachexia strumipriva,' and Reverdins' 'operative myxoedema'; and very closely associated with endemic cretinism. Lombard (1883) in summarizing previous work on the physiology of the thyroid, stated, in effect, that the thyroid is of major importance in the normal development of body and intelligence in children, and in its maintenance in adults.

The surgical mistakes which resulted in 'operative myxoedema' soon gave rise to attempts to replace the lost activity of the thyroid gland. With the advent of replacement therapy came further knowledge of the exact function of the gland. A very important note on the possible treatment of myxoedema was published by Schiff (1884). He found that his dogs could be safeguarded against some of the consequences of thyroidectomy by transplantation of a thyroid gland from another animal of the same species. He also made the suggestion that an emulsion, or an extract of the thyroid, may have produced the same result if injected into, or ingested by, the animal. Following the lead of Schiff, Murray (1891) showed that relief from myxoedema symptoms could be maintained by hypodermic injections

of an extract of the sheep thyroid. Fox (1892) found that the symptoms of myxoedema were relieved by the oral administration of thyroid. Ord and White (1893) observed that excess administration of thyroid caused an increase in nitrogen excretion, while Hadden (1882) had already cited examples showing that the nitrogenous excretion of myxoedema patients was abnormally low. Müller (1893) discovered that in exophthalmic goitre (Graves' disease) the nitrogenous metabolism was increased. This led to the important work of Magnus-Levy (1895) which showed that the rate of metabolism is abnormally high in Graves' disease (where the thyroid is hyperactive) and abnormally low in myxoedema. Further studies on the physiological activity of the thyroid have been elaborations of the work of Magnus-Levy, and have supported his discovery of the metabolic regulator activity of the gland. The work of Du Bois (1916) has amply confirmed Magnus-Levy's discovery of the association between thyroid activity and metabolic rate. Aided by the Sage calorimeter in determining total metabolism, Du Bois was able to establish the conclusion that the increase in metabolism associated with exophthalmic goitre is directly proportional to the severity of the clinical symptoms. In general, it may be said that very severe cases of hyperthyroidism show an increase of 75 per cent or more in total metabolism; severe cases, 50 per cent or more; and moderately severe and mild cases less than 50 per cent. In cretinism and myxoedema, the metabolism rate may be 25 to 50 per cent below the normal level. Administration of thyroid raises the metabolism in these conditions, and has a similar, though less consistent, effect on normal men. No other gland extract which has been tried produces such an effect in any significant

degree. Except for the activity of the thyroid in relation to the other endocrines, the metabolism regulating function is generally recognized as its fundamental rôle in the physiology of the organism.

Just as the exact rôle of the thyroid in the general physiology of the organism has been known only during the past 50 years, so it is with the significant features of the biochemistry of this gland. The therapeutic value of certain substances, now known to contain iodine, in the treatment of goitre, according to Marine (1927) was known to the Chinese fifteen centuries before Christ. Of these substances, sponge ash was the best known and was widely used in the time of Hippocrates. Dioscorides (first century A.D.) referred to the use of the sponge ash in the treatment of goitre, as did also Galen and Pliny.

It was but a few years after the isolation by Courtois in 1812 and the identification of iodine as an element by Gay-Lussac in 1815, that the element was found to exist in abundance in the sea sponge. Following this lead, Coindet (1820) was able to show that it was the iodine in the time-honored sponge remedy that actually produced recovery from goitre. He administered the iodine to his patients either in a solution of potassium iodide, or in an alcoholic tincture. The dosage began at 1.5 grains of iodine daily, increasing to 3.0 grains after several weeks. Under such treatment his patients showed a constant diminution in the size of the goitre until at about 8 or 10 weeks from the first dose, the malady had completely disappeared. Almost simultaneously, yet independently, Formey (1823) discovered the same phenomenon, and published a note on the successful treatment of several cases of goitre with iodine.

One would think that the significant findings on the relation of thyroid to

goitre would very soon have led to attempts to show whether or not the thyroid was in any way related to iodine metabolism in the body. However, it remained for Baumann (1896) to show first that iodine in a firm organic combination is a normal constituent of the thyroid gland. He treated the gland substance with 10 per cent sulfuric acid and obtained a brownish powder containing about 9 per cent iodine. He named his newly discovered product iodothylin.

Further investigations of the chemical nature of the thyroid gland were of slight significance until Kendall (1915) reported the isolation from thyroid of a crystalline compound containing 60 per cent of iodine. The same investigator (1916) showed that his iodine-containing compound was the active constituent of the thyroid gland. Later (1919) Kendall named the crystalline compound thyroxin, and in the same year (1919) Kendall and Osterberg reported that the analysis of thyroxin gave the following percentages: carbon, 22.56; hydrogen, 1.70; oxygen, 8.20; nitrogen, 2.39; and iodine, 65.10. From these percentages, and the molecular weight determination of 586, Kendall's empirical formula for thyroxin turned out to be $C_{11}H_{10}O_4NI_4$.

Harington (1926) showed that Kendall's determination of the empirical formula of thyroxin was erroneous, and on the basis of more elaborate experimentation, found the empirical formula to be $C_{15}H_{11}O_4NI_4$. In the same year (1926) Harington and Barger synthesized thyroxin and proved experimentally that the synthetic product had the same effects as natural thyroxin, i.e. thyroxin extracted from the gland.

THYROID FEEDING OF VERTEBRATES

From the oral administration of thyroid extract in the replacement therapy for myxoedema it was but a slight step to

early attempts to produce hyperthyroidism in vertebrate organisms other than man by feeding thyroid extract. Chief among the vertebrates that have been used in studies of hyperthyroidism produced by feeding or injection of thyroid extract are the amphibia, birds, and mammals.

In order to understand the manifold reactions of thyroid feeding and thyroxin injections on the vertebrate organism, it is necessary to review the normal physiological functions of the thyroid in the body. The thyroid occupies a central position among the endocrine glands inasmuch as many important physiological processes are subject to its regulation. Metamorphosis, growth, metabolism, temperament, and volume as well as composition of the blood of the body are directly dependent upon the action of the thyroid. The thyroid effects are produced partly by the direct influence upon the cells of the body, partly by way of the central nervous system, and partly by the effects upon the other organs of internal secretion. In contrast to other endocrine organs, the thyroid, according to our present knowledge, gives rise to only *one* hormone. This does not, however, imply that the principle hitherto regarded as 'the thyroid hormone' may not exist in several chemically distinct, yet inter-related variants. Such an assumption would, in truth, explain the fact that different preparations of the thyroid produce different effects in the same organism. This phenomenon is amply shown in a later section on the thyroid treatment of protozoa. The above assumption would also, to some extent at least, explain the variation in quality of thyroid function of the different vertebrates (also shown in the work on Protozoa and the frog) as well as the variation in response of different vertebrate organ-

isms to the same extract. This latter fact was one of the first phenomena to be observed as a result of thyroid feeding. Hence, the early papers are concerned mostly with the variation in tolerance of vertebrates to the oral administration of the extract.

Cunningham (1898) reported a series of three experiments in hyperthyroidism: (1) subcutaneous injections of thyroid extract in dogs and rabbits; (2) feeding fresh sheep thyroid to chickens, rabbits, dogs, cats, monkeys, and man; and (3) feeding desiccated thyroid extract to chickens, rabbits, dogs, cats, monkeys and man. Toxic symptoms resembling those in exophthalmic goitre in man were produced by the injections, but the conclusion was reached that the effect was not specific for thyroid since the same results were obtained with extracts of other glands. Feeding the desiccated extract produced toxic symptoms also, and the author concluded that the toxic effects were not due to any specific thyroid effect, but to some decomposition product, since the fresh thyroid had no toxic effect. Carlson, Rooks, and McKie (1912) fed thyroid to dogs, foxes, ducks, cats, rats, chickens, pigeons, guinea pigs, rabbits, monkeys and man, and the organisms were tolerant to large doses in the order of the above list. That is, foxes and dogs were most tolerant, and man least. The authors concluded that the former are more tolerant because they are used to a carnivorous and omnivorous diet. The toxic effects of thyroid feeding produced loss of weight and gastroenteritis—symptoms which the authors observed were not the same as those of exophthalmic goitre in man. It will be noted, however, that in cases where excess thyroid extract has been fed in the treatment of myxoedema, symptoms similar to those mentioned have been observed. (Zondek, 1935, pp. 198–199).

Amphibians

A great amount of work has been done along the line of experimental hyperthyroidism in the amphibia, especially with reference to the effect of thyroid feeding on metamorphosis. The work of Allen (1916) and Hoskins and Hoskins (1917) on the removal of the thyroid gland in amphibian larvae clearly indicates that this gland is normally indispensable to metamorphosis in these forms. In the above experiments, the thyroid gland was removed soon after its first appearance (5 or 6 mm. total length stage) and hence had never functioned in the tadpole's body. The absence of the thyroid (Allen, 1918; Hoskins and Hoskins, 1919) did not in any manner affect the rate of growth nor the processes of early development up to a certain definite stage. At that particular stage, however, which, of course, varies among genera, and even among species of the same genus, developmental processes abruptly ceased, while normal growth continued. The thyroidectomized tadpoles continued to increase in size, but would not metamorphose further without the administration of some extract of the thyroid. In normal tadpoles, the action of the thyroid then seems to promote metamorphosis and growth simultaneously and at an even pace.

Removal of the thyroid body in frog tadpoles not only inhibited external metamorphosis, but equally influenced the development of the internal organs. Allen (1918) noted that the alimentary tract in the thyroidectomized tadpoles retained its characteristic larval form, and that the brain was hindered in development. Terry (1918) showed that the growth and ossification of the bones of the tadpole after thyroid extirpation were abruptly hindered. In contrast to the above results from the removal of the frog thyroid, is the quite normal develop-

ment of the sex glands, reported by Allen (1918). Swingle (1918) also showed that thyroid feeding did not accelerate the development of the germ cells or sex glands. The point of interest here, as noted by Allen, is that these data confirm once more Weismann's hypothesis of the independence of the germ plasm from the soma.

Further investigations that have been of importance in confirming the above conclusions on the metamorphosis regulator function of the thyroid are the various studies on the effects of thyroid feeding and thyroxin injections in amphibian larvae. The earliest in this field was Gudernatsch (1913a) who found that when thyroid substance was given as food to tadpoles of *Rana temporaria* and *R. esculenta*, it caused a precocious differentiation of the body, but suppressed further growth. The thyroid-fed tadpoles began to metamorphose a few days after the first feeding, and many weeks before the control animals. This same worker (1913b) carried out experiments to determine the least amount of thyroid food necessary to produce acceleration of differentiation, and to determine whether or not the tadpoles could recover from the thyroid shock if later put on other food. When the thyroid was fed for only 24 hours, it caused a hastening of differentiation in the tadpoles. A feeding of three days was enough to give the fastest rate of differentiation; a rate that could not be increased by longer feeding. Recovery from the thyroid influence was extremely rare. Only 10 individuals out of 800 were able to regain normal growth when changed to a normal diet. Morse (1914) concluded that the specific effect of thyroid, discovered by Gudernatsch, in shortening the period of metamorphosis in frog larvae was basically due to iodine, which is associated in some way with the amino-acids composing the complex iodized

globulin of the thyroid. This worker also found that inorganic iodine preparations did not produce the accelerating effect. West (1914) fed frog tadpoles daily with commercial (Parke Davis and Co.) sheep thyroid tablets. At the end of 17 days, the thyroid-fed animals had metamorphosed very rapidly and had reached the stage of the development of the fore-limbs, whereas the controls showed no metamorphic changes, and only a slight growth. The experiments of Abderhalden (1915) indicated that tadpoles of *Bufo vulgaris* fed thyroid extract completely metamorphosed in 8 days, while the thymus-fed controls showed only slight evidences of metamorphosis. Of particular interest is the fact that metamorphosis failed to set in or remained imperfect when the animals were fed with thyroid from cases of goitre or Graves' disease (Abderhalden and Schiffmann, 1922).

Romeis (1915) summarizing his studies on the thyroid feeding of *Rana temporaria*, *R. esculenta*, and *Bufo vulgaris* drew conclusions that substantiated the findings of Gudernatsch. He found that the loss of weight of the thyroid-fed tadpoles was due to the loss of water associated with an increased rate of metabolism. The thyroid-fed animals showed an increased rate of metamorphosis and a decreased rate of growth as compared with the muscle-fed controls. Kahn (1916) found that frog tadpoles fed finely minced horse thyroid started metamorphosing much earlier than controls fed on either liver or thymus. A microscopic study showed that the thyroid-fed animals had a smaller thyroid gland, a larger thymus, and a much larger hypophysis than the animals fed on the control diet.

Swingle (1918) fed thyroid to the larvae of *Rana pipiens* and *Rana catesbeiana*, and made some interesting observations. The thyroid material (Armour and Co.) was

mixed with wheat flour in the proportion of 3 grams of thyroid to 10 grams of flour, with the addition of enough water to make a thick paste. The paste was dried, and crumbled into the water containing the tadpoles. The thyroid-fed animals ceased to grow after the administration of thyroid, and 5 days after the first feeding they presented characteristics quite different from the controls fed on fresh beef liver. The bodies of the thyroid-fed larvae appeared more slender and the heads more elongated than those of the controls. They also revealed indications of tail involution. Eight days after the first feeding of thyroid, the experimental animals had developed limb buds, and the elongated appearance of the head, previously noted, had increased. The body had become emaciated and pronounced atrophy of the tail was observed. When contrasted with the thyroid-fed larvae, the controls revealed none of the changes enumerated, and had only increased slightly in size during the 8-day period. This same worker (1919) reported that iodine or its inorganic compounds administered to frog tadpoles induced precocious metamorphosis.

The experiments of Kollmann (1919) showed that the effects of thyroid feeding on tadpoles may be quite variable. In summarizing his results, Kollmann called attention to the fact that the age of the tadpole, as well as the state of nutrition must be taken into consideration in discussing the problem. According to Champy (1922) thyroid substance added to water containing frog tadpoles accelerated cell division in some zones and tissues far beyond normal velocities. Miyagawa and Wada (1925), studying the effects of thyroid feeding on tadpoles concluded that the extract inhibits growth and promotes differentiation of the cells of the tadpole's body. Helff (1926) re-

ported some experimental work on the oxygen consumption of thyroid-fed larvae of *Rana pipiens*. A progressive increase of 79 per cent in oxygen consumption per gram of body weight was found to occur in the metamorphosing (thyroid-fed) larvae as compared with the controls. The increased metabolic rate found to exist was regarded by the writer as a secondary phenomenon of metamorphosis, and not to be viewed as a causative factor of that process. Gunthorp (1932) working with three different species of frog tadpoles found that all reacted similarly to thyroid treatment. Extracts of the thyroids of a number of vertebrates were used, and the responses of the tadpoles were recorded as follows: (1) relatively slow development came as a result of feeding calf, raw beef, cooked beef, pig, and flounder thyroids; (2) relatively rapid development came as a result of feeding dog, human, buffalo, and bear thyroids; and (3) development intermediate between the above two extremes came as a result of feeding cat thyroid. Metamorphosis was found to be accelerated in direct proportion to the amount of iodine present in the gland substance, irrespective of the source.

A very thorough report on the effects of thyroid feeding of tadpoles was made by Puckett (1937). Following the procedure of Swingle (noted above), this worker was able to produce precocious metamorphosis in the tadpoles of *Rana sylvatica* by feeding a thyroid-flour paste [3 gm. thyroid (Armour's) to 10 gm. flour]. The controls of this experiment were fed a similar flour paste without the thyroid extract. Metamorphic changes began to appear 3 days after feeding. The first change evident was a reduction in size of body, which lost its rounded tadpole shape, and gradually assumed the slender triangular form characteristic of the frog. Other changes appearing at this time were

the disappearance of the tail fin, the elevation of the eyes, the disappearance of the horny jaws, and a migration of the mouth opening from its original ventral position to a more anterior one. During all this time, there was a rapid growth of the hind limbs, so that by 6 days after thyroid feeding the hind limbs were several millimeters in length, and possessed the typical divisions of the adult limb. At about the sixth day after feeding, the left fore-limb appeared, and at about the eighth, the right fore-limb. Except for an incomplete resorption of the tail, the animal at 9 days was a midget frog with four functional limbs, and capable of existing, for a time at least, out of water. The control animals showed no metamorphic changes during this time except an increase in growth, and differentiation of the hind limbs.

Thyroxin (the isolated hormone of thyroid) in very low concentrations affects the metamorphosis of tadpoles in a manner quite similar to thyroid extract. Romeis (1923) carried out a series of experiments on thyroxin treatment of frog tadpoles. His method consisted principally in immersing the animals in solutions of known concentrations of the hormone for definite periods, and at definite intervals, after which they were placed in normal tap water. He found that the extent and character of the changes produced by thyroxin varied with the concentration of the hormone, the number of treatments, and with the age of the animal at the time of treatment. A definite acceleration in development was produced by concentrations as low as 1:1,000,000,000, if the larvae were kept in the solution during the complete time of their metamorphosis. Gaddum (1927) observed that the most obvious change in frog tadpoles following 24 hours immersion in dilute solutions of thyroxin was a rapid diminution in size.

This appeared to be due partly to the hastening of normal processes of metamorphosis and partly to the wasting which is associated with an increase in metabolic rate. Allen (1932) exposed tadpoles of *Bufo halophilus* to thyroxin solutions ranging in concentration from 1:2,000,000 to 1:1,000,000,000 at a stage well prior to the rapid changes of metamorphosis. No response of any portion was observed in solutions of thyroxin of concentrations less than 1:200,000,000, and in that dilution the response was only slight. The different parts studied were arranged in order of responsiveness to lower concentrations of thyroxin as follows: (1) alimentary tract; (2) limb-buds; (3) changes in the color of the gall bladder, tongue growth, and loss of horny jaw; and (4) reduction in the length of the tail, and reduction in the length of the body. The speed of response was in proportion to the concentration of the thyroxin used up to a certain maximum limit, beyond which greater concentrations did not give greater rate of development. Allen concluded that the influence of thyroxin is proportional to the age of the tadpole, being slight in the tail-bud stage, and becoming greater in the 20 mm. total length stage. Alphonse and Baumann (1935) confirmed the conclusions of Romeis and Allen, and stated that thyroxin accelerates metamorphosis in batrachian tadpoles in proportion to the age of the tadpole, the dosage, and the time of exposure to the hormone.

Studies on thyroid feeding of the axolotl, an amphibian which normally lives its entire life in the larval stage, show the remarkable power of the gland substance in inducing metamorphosis. Huxley (1920) was the first to discover that the axolotl will metamorphose as a result of thyroid feeding. He used two young (6 to 12 months old) specimens for

his experiment, and kept them in a tank of water at an average temperature of 15°-16°C. They were fed on ox thyroid, at first three times, and later twice, a week. Within two weeks after the first feeding of thyroid, the axolotls presented distinct alterations in color, and a beginning of the resorption of gills and fins. Within three weeks metamorphosis had been completed. The animals climbed out of the water, able to walk quite well. The skin was as dry as that of any terrestrial salamander.

According to Giacomini (1926) fresh beef thyroid given orally stimulates complete metamorphosis in axolotls from one month upward in age. In adults over two years of age, this worker obtained metamorphosis with a minimum dose of 0.2 to 0.1 gm. of fresh beef thyroid given in single doses. Bělehrádek and Huxley (1927) found significant increases in metabolic rates (oxygen consumption) during metamorphosis of axolotls (larval *Amblystoma tigrinum*) induced by thyroid feeding. In a very thorough study of the metamorphosis of the axolotl Lipchina (1929) noted that the rate of metamorphosis is directly proportional to the concentration of the thyroid extract; but found no concentration capable of producing the complete change in less than 25 days. The rate of metamorphosis had no apparent relation to pigmentation or sex of the animals, but was related to age. The most rapid rate was observed in animals about 6 months old, while the slowest rate occurred in adults. Ingram (1929) demonstrated that the subcutaneous implantation of iodine produced complete metamorphosis in the Colorado axolotl. Balthasart (1932), studying the effects of thyroid feeding and thyroxin injections on the axolotl, concluded that the duration of metamorphosis was inversely proportional to the percentage of iodine

in the extract. This worker also believed that iodine is the active agent in the hormone, and that in order for it to act, the iodine must be associated with an organic substance which renders it assimilable without interfering with its action.

The evidence appears conclusive that thyroid feeding of amphibians results in an acceleration of cell division and differentiation in various regions of the body, and in an acceleration of normal metamorphosis. This is merely an accentuation of the normal rôle of the thyroid in the metamorphosis of these animals. Abundant evidence also indicates that thyroid feeding causes complete metamorphosis in the axolotl, a form which normally does not metamorphose. These reactions are independent of sex, but are directly related to the age of the organism, the concentration of the extract, and the time of exposure to the hormone.

Birds

The normal action of the thyroid in the physiology of birds has been adequately demonstrated by Schwarz (1930) in his studies on hypofunction, transplantation, and extirpation of the gland in fowls. His first observation was that the size of the gland was not related in any way to the sex of the fowl. In two hens where hypofunction was discovered, feather development was greatly retarded. This, he held, was a confirmation of the theory that thyroid function is responsible for the velocity of feather growth. In his transplantation experiments, this investigator grafted half of the thyroid body from several types of fowls three-and-a-half months of age into Plymouth Rocks of the same age. In most instances the transplanted tissue underwent necrosis, and was completely resorbed within 20 days. Only on several occasions did a

small amount of the tissue remain to grow and become active. The excess of thyroid products by resorption did not affect the weight of the fowls, but caused a definite darkening of the feathers. There was also an increase in body temperature of the experimental animals as compared with the controls, but the author concluded that much more investigation of the question was necessary before any definite conclusions could be made on this point. Thyroidectomy in cocks and hens resulted in a retardation of growth, a diminution in body weight, and distinct changes in the structure of the feathers. The feathers of the thyroidectomized cock were narrow and pointed, but displayed no change in pattern. The sex of the fowl was not impaired by the absence of the thyroid gland. The hen decreased in weight, and at 7 months after thyroidectomy showed extreme anemia. At 10 months she died. The few feathers that had developed after removal of the gland were of a type intermediate between the two sexes. They were somewhat narrow and pointed, a few approaching the male type. From these observations it appeared to Schwarz that pigmentation and growth of feathers in fowls are fairly dependent upon metabolic rate. Increased thyroid function causes increased pigmentation up to a point where metabolism concerns the oxidation of melanin, at which time depigmentation occurs. Hyperfunction of the thyroid causes an increase in the growth of feathers; hypofunction causes retardation in feather development. The form of the feather is held to be more clearly associated with the sex of the fowl, than to the thyroid. Parkes and Selye (1937) made a further contribution to our knowledge of thyroid activity in fowls by observing the effects resulting from thyroidectomy in several breeds of chickens. The feathers which grew during hypothyroidism

in both sexes were elongated, and showed a loss of barbules leading to fringing. Deposition of black pigment was hindered in Brown Leghorns and Silver Dorkings, but was increased in Anconas.

Landauer (1929) reported a morphological and histological study of a dwarf Rhode Island Red pullet. The plumage of this bird was rugged, the skin and feathers were unusually dry. The beak and tongue were grossly deformed and the eyes had puffy patches around them resembling oedema. All the bones of the body showed a retardation in development, and the marrow in many had degenerated. The skull showed striking brachycephaly. The thyroid in this bird was enlarged, and the greater part of the gland consisted of a plastic tissue without colloid. It was suggested that the dwarfism of this chicken was analogous to human myxoedema infantilis. The report also included measurements of five other specimens revealing the same type of dwarfism. These observations show in a clear-cut manner that the normal function of the thyroid is necessary in the development of the skeleton as well as of plumage in the domestic fowl.

Riddle (1928) has shown the existence of at least four "small thyroid" and four "large thyroid" strains of pigeons. The fact that these strains breed true over numerous successive generations is ample evidence that genetic factors for thyroid size do exist. If the size of the gland gives any indication of the quality of its function, it is easy to see that the normal action of the thyroid will vary among strains of the same species. In like manner the oral administration of thyroid will produce a variety of effects among different strains. With these facts in mind, it will be somewhat easier to understand the discrepancies and disagreements

in the studies on experimental hyperthyroidism in birds, now to be discussed.

Experimental hyperthyroidism by feeding or injecting thyroid extract in birds has received the attention of a great number of workers during the past 15 years. Among the most common results of thyroid feeding in fowls are excessive moulting and depigmentation of regenerated feathers. B. Zawadovsky (1925) and M. Zawadovsky (1925) in their experiments with fowls, discovered that large doses of thyroid caused a marked loss of feathers, and that the lost feathers were replaced by others which were completely colorless or white in varying degrees depending on the dosage. From this they concluded that the thyroid gland plays a specific rôle in the regulation of the growth and moulting of feathers, and in their pigmentation. Sainton and Peynet (1926) confirmed the observations of Zawadovsky and noted that the administration of thyroid to an adult black hen resulted in the whitening and falling out of the feathers in certain areas. Zawadovsky (1926), in confirming his earlier work on moulting, regeneration and depigmentation of plumage noted that single doses of extract were effective, and that equal success may be obtained from the feeding of sheep, oxen, and horse thyroid. Kendall's thyroxin produced the same result, except that it was 500 to 1,000 times more effective. Control fowls fed with muscle or suprarenals showed no effect even when fed with extremely large doses. Injections of organic iodine (in Lujol's solution) or implantations under the skin in crystal form caused only slight changes. Giacomini and Taibell (1927a and 1927c) reported a moderate partial shedding of plumage in fowls consequent to thyroid feeding. Cole and Hutt (1928) reported that raw and desiccated thyroid fed to male and female fowls caused

moulting, but they observed no depigmentation of new feathers as others had reported. These workers found that desiccated extract affected feather growth more than raw thyroid. Zawadovsky and Titajév (1928), in further confirmation of Zawadovsky's earlier work, found that thyroxin injected into fowls caused depigmentation of the plumage and moulting. Crystalline iodine caused a slight depigmentation but no moulting, while injections of iodotyrosine and tryptophane with iodine caused but a feeble depigmentation and moulting. Martin (1929) found that thyroid feeding was followed by a rapid moult and depigmentation of new feathers. A study by Zawadovsky and Lipchina (1929) showed that the addition of thyroid extract to a seed diet of hens caused an increase in the growth of feathers, rapid moulting, depigmentation of new feathers, and a redistribution of pigment in the neck feathers. Horning and Torrey (1923) found that when Brown Leghorn chicks from the age of two weeks were fed dried thyroid daily, the development of adult plumage, both as to form and color, was delayed. The general color of the birds at seven months was darker than normal, because of an increase in black pigment in the hackle, shoulder, back and saddle feathers. The brilliant red, characteristic of the normal hackles, back and saddle feathers, was poorly developed or lacking and its place was taken for the most part by yellow. The color change was associated with a structural change, the increase in width of the dark central stripe being accompanied by an increase in number, and a change in distribution of the barbules on the back.

The work of Domm (1929) on the thyroid feeding of Brown Leghorn fowls is in complete agreement with that of Horning and Torrey. In this study,

Brown Leghorn cocks were fed Armour's powdered desiccated thyroid in dosages which started at 400 mg. per fowl on alternate days, and were gradually increased until at the end of seven months each fowl received 750 mg. daily. The first effects observed were modifications in the color and form of new feathers on the hackle, back, saddle and wing-bow. These feathers, which are normally brilliantly colored in shades of red and yellow, were replaced by others which were almost entirely black. The hackle and saddle feathers were shorter than normal and revealed broadened rounded tips. All of the thyroid-fed birds revealed accelerated replacement of feathers. Kříženecký and Podhradský (1927) had shown that pure bred male and female fowls hyperthyroidized by thyroid feeding were accelerated in moulting and in feather growth. Partial albinism was reported as a result of thyroid treatment; this character, however, lasted only while the extract was being fed. No changes in feathers were observed as a result of thymus feeding. Gericke (1934) found that desiccated thyroid in large doses (1 to 1.5 gm. per kilogram body weight) produced white feathers in females and reddish feathers in the males of Australorp fowls. Capons fed 0.5 gm. to 1 gm. per kilogram moulted profusely and the new feathers developed much quicker than in the controls. The author suggested that thyroid feeding might be employed in bringing about uniform moulting in laying hens, and in encouraging feather growth in young stock.

Sainton and Simonnet (1930) demonstrated that the thyroid was the only endocrine organ extract which would cause a loss of feathers, blanching, and a rapid regeneration of feathers in the fowl. The above modifications were obtained with doses as small as 0.10-0.30 gm. daily.

Ingestion of normal thyroid in a total amount of 6.5 gm. caused a blanching of feathers within 6 days. Ingestion of thyroid from simple goitre produced no effect, even when fed in dosages totaling 33.5 gm. Ingestion of thyroid from exophthalmic goitre produced blanching in the same manner and time as with normal thyroid. These writers concluded that some factor other than iodine content was responsible for the effect, inasmuch as the iodine percentages were made identical in the latter two experiments.

Later (1931) these workers performed an experiment in which a cock and two hens were fed tablets containing 30 centigrams of thyroid extract "délipeide de Byla", at first one a day, and later one every other day. These doses were chosen because they appeared not to cause any harmful effects in the animals during the experimentation. In one hen depigmentation was observed on the fifteenth day after feeding, in the other 60 days after feeding, and in the cock, 50 days after feeding. Egg laying and fecundity were not affected by hyperthyroidism, nor was the volume or general constitution of the egg changed. Five of these eggs were hatched by a normal hen, and five chicks developed normally, although their growth in weight showed a slight acceleration over the controls. Several days after hatching, these chicks, *without themselves having received thyroid treatment*, showed a definite blanching of feathers on the wings and neck. The blanched feathers became permanently established at three months, and were in many respects similar to the modifications noted in the parents as a result of thyroid treatment. These facts indicated to these writers that the phenotypic character acquired by hyperthyroidism is hereditarily transmissible. Whether the modifications which were passed on were due to the

thyroid effects on the egg, or to some other mechanism, the authors could not say.

Another interesting result of thyroid feeding of fowls is the alteration of the secondary sexual type of plumage to the female type that has been observed by several investigators. Torrey and Horning (1922) found that Rhode Island Red, White Leghorn, and Golden Sebright male fowls fed thyroid developed female feathering in 10 to 15 weeks. The work of Cole and Reid (1924) also indicated that male fowls fed thyroid extract developed feathers of a definitely female type. They noted further that iodine and its compounds did not produce such an effect. Torrey and Horning (1925) substantiated the above conclusions by further investigation, and pointed out that the active element in thyroid extract does not act through the thyroid gland of the fowl, but directly affects the division of cells in the feather germ. The work of Brambell (1926) also indicated that thyroid fed to young chicks caused hen feathering in cocks—a phenomenon which the author believed not to be traceable to the gonads. To determine whether hen feathering after moult is related to a particular sex Giacomini and Taibell (1927b) experimented with males and females of Padun and Arno Valley fowls. Besides the bleaching of feathers, modification in pattern occurred in about the same degree in the two sexes. Not only was there a feminization of male feathers, but also a change in the pattern in both sexes. Hence the conclusion was drawn that thyroid affects the morphogenesis of feathers independent of sex. Another paper (1927d) by these experimenters confirmed their earlier finding that the pattern of new feathers grown after moult caused by thyroid feeding was independent of the gonads. Cole and Hutt (1928) reported that the color and

pattern of the feathers in male birds of Hamburg, Barred Rock, and Silver Wyandotte were changed to female patterns subsequent to thyroid feeding. The most interesting changes were observed in the Silver Wyandotte male receiving desiccated thyroid. This bird grew female feathers on the neck, wing-bow and saddle. The neck feathers tended toward solid black rather than the typical black feather with white lacing. On the wing-bow, however, where the male feathers had been white with a black base, there were produced feathers entirely female both in structure and pattern, i.e., white with black lacing. Similarly on the saddle, the new feathers were white with black lacing, whereas those of a normal male are black with a white margin.

Podhradský (1930) found that thyroid feeding of castrated roosters produced changes in the typically male feathering tending toward hen feathering. The most notable changes were those related to color intensification, width, and length of feathers. The action of the thyroid in feather development appeared to be complementary to that of the testes, though independent from it. Perfect feathering according to this investigator, is due to the hormone activity of both the testis and the thyroid gland.

The work of Brambell (1926) indicated that thyroid extract fed to young chicks produced a soft, loose plumage, lighter in color than that of the controls. Zawadovsky (1926) found that the regenerated feathers following a rapid moult caused by thyroid feeding were smoother and more tender than the original plumage. He suggested that a practical application of this work might be found in the fact that more feathers of a softer and smoother texture might be obtained with an increase in number of moults per year. Martin (1929) observed, in his

thyroid-fed chickens, a change in texture of the plumage from the normal to a silky quality. Champy and Morita (1929) found that young chicks treated with very small doses of thyroid showed changes in certain groups of feathers. Those of the back, neck, tail and breast presented characters of growth and color closely resembling the adult type.

Effects other than those related to the plumage have also been reported as the result of feeding thyroid to fowls. Sainton and Peynet (1926) reported a rapid loss of weight, a cessation of egg laying, a rise in temperature, increased excitability, and a diminution in volume and a paling of the comb following thyroid feeding. The effect of thyroid feeding on egg laying in fowls was reported by Giacomini and Taibell (1927a). They found that large quantities of thyroid fed over a short period of time to a pure strain of White Leghorn hens resulted in a prompt and complete cessation of egg laying; followed, after a month, by resumption and cessation again in the normal inactive period. The same total amount of thyroid fed in smaller doses over a longer period of time did not affect egg laying during the regular period of egg production, but decreased the length of the period of inactivity. In the same year (1927c) these workers confirmed their work concerning egg laying, and demonstrated further that when thyroid was fed from an early age, egg laying was retarded in association with the slowing of body growth and sexual maturity. Cole and Hutt (1928) reported that raw and desiccated thyroid fed to male and female fowls did not in any way affect egg laying or body weight. The authors concluded that their negative findings concerning weight and egg laying were due to the relatively small dose (59 mg. daily per pound of live weight) of the extract

fed. Zawadowsky, Liptschina, and Radsiwon (1928) presented data confirming the results of Giacomini and Taibell; namely that large single doses (1-2 gm. daily) of thyroid gland fed to hens abruptly stop egg laying. Small doses (0.01 to 0.05 gm. daily), however, increased the egg production of hens that were originally poor layers. Here the statistics indicate that the number of observations was small, and the egg-laying data were variable, so that much more careful experimentation and observation is necessary if the work is to have any particular critical value. Crew (1925) had previously shown that small doses of thyroid fed over a long period of time caused a general rejuvenation in old fowls, and a consequent improvement in the laying power of hens. Asmundson and Pinsky (1935) found that when desiccated thyroid extract was fed to laying hens in such amounts as to supply about 1.0 mg. of thyroid per 1,750 grams of body weight, the weight of the yolk was reduced. There was no effect on the amount of albumen secreted, while there was a significant increase in the amount of shell. The rate of growth of the ovum was reduced by thyroid feeding. The weight of the bird was reduced in every case where desiccated thyroid was fed.

Of particular interest is the fact that birds offer a very high resistance to the thyroid hormone. The work of Martin (1929) on the effect of excessive dosages of thyroid on the domestic fowl showed that single doses (8-30 gm.) of desiccated thyroid, although producing physiological shock, are not lethal to hens. Doses of 30-35 gms. were lethal to two of three capons, but cockerels withstood doses as large as 35 gms. Martin found further that large doses of thyroid produced a loss of weight and a depression in body temperature, especially in capons. A loss of

weight varying from 0.007 percent to 0.08 percent of the total body weight was observed 48 hours after feeding. This loss, however, was made up, so that by the end of 31 days the thyroid treated had gained approximately the same weight as had the controls. The largest drop in temperature was noted also immediately following thyroid treatment, but here the data present enormous variations and hence cannot be analyzed qualitatively. The conclusion was reached that the capons were more susceptible to the thyroid effects probably because of the lack of compensatory hormones from the testes.

Several birds other than the domestic fowl have been used for studies in experimental hyperthyroidism. In nearly all cases the results are similar to those obtained in thyroid feeding of chickens. Zawadowsky (1926) confirmed his earlier work on moulting, regeneration, and depigmentation of plumage by thyroid feeding of fowls, and noted further that similar moulting can be induced in the pigeon, daw, bullfinch, starling, duck, goose, and peacock. The work of Occhipinti (1927) on the quail showed that thyroid feeding of the male causes loss of weight and loss of feathers on the back. The lost feathers were replaced by others of a rougher texture and a duller color, and in less than two months, male birds developed female feathering. The author believed that the effect of thyroid feeding on plumage is secondary, in the sense that the thyroid stimulated the suprarenals and that it is the secretion of those glands that directly affects plumage. Zawadowsky and Rochlin (1927) found that thyroid extract caused very heavy moulting in the partridge and kestrel, and moderate moulting in the screech-owl, bullfinch and jay. None of these showed any depigmentation of the

new feathers. The common crow, however, which moulted only slightly, grew new feathers lacking in pigmentation. From these observations the authors suggest that there are two independent pituitary effects of thyroid on birds—moulting and depigmentation. A study by Larionov (1930) indicated that the feeding of 10 to 20 mgm. of powdered thyroid in water to bullfinches accelerated the rate of regeneration of feathers of the upper wing coverts, the old feathers having been plucked at the start of the experiment. This acceleration was most marked (approximately 20 percent) in a series of six birds fed 20 mgm. daily, and was observed in comparison with both controls fed powdered muscle, and with normal regeneration of feathers in the experimental birds prior to treatment.

Another study was made by Larionov (1931) on the differential effect of size of dose and time of administration of powdered thyroid by mouth on the speed of regeneration of feathers in the bullfinch. The minimal dose giving any noticeable increase in speed of regeneration compared with that of controls fed powdered muscle was 10 mgm. No effect was observed with 3 mgm. and the maximum effect came with 20 mgm. If feeding was delayed 3, 6, 10, or 15 days from the time of plucking, there was a comparable delay in the beginning of acceleration of feather development. The 10- and 15-day delay groups showed no acceleration. From these observations, Larionov suggested that the thyroid exerts its action only during the first stages of feather development.

Miller (1935) experimenting with thyroxin injections into deplumed and castrated male and female sparrows found that the regenerated plumage was modified in all, but that the general effects were greatest in the castrated birds. The

seasonal sex cycle of the male, as indicated by bill color, was accelerated by thyroxin injections. Hardesty (1935) reported that thyroxin injections in doses of 4 mgm. or more produced general moulting in the guinea fowl, with the regenerated feathers appearing sooner than normal. The color and pattern as well as the structure of the regenerated feathers were changed. Raspopova (1930) found that moulting in geese could not be induced in the spring when the animals were fed as much as 40-50 gms. of thyroid extract. When the dosage of 100 gms. was fed, or when an injection of 50 mgm. of thyroxin was made, a heavy moult resulted. The regenerated feathers after thyroid moult showed an increase in the amount of down. Thyroid extract fed in the fall (50 gm.) caused a complete moult and a considerable increase in down. Injections of 30 mgm. thyroxine caused the same effect. The evidence indicates that thyroid is more effective in producing a moult after the regular moulting season, than during the period of normal shedding.

From the above studies of hyperthyroidism in birds, several generalizations can evidently be made. Thyroid feeding or thyroxin injections in birds result in (1) moulting; (2) acceleration and depigmentation of the regenerated feathers; and (3) changes in pattern and structure of the regenerated feathers. These effects seem to be independent of the gonads and of the thyroid gland of the bird, but result from changes in the feather germ itself. The effect of thyroid feeding on body weight and egg laying is apparently in some degree proportional to the quantity of the gland substance fed.

Mammals

As has been stated previously, the thyroid is fundamentally associated with

metabolism, growth, metamorphosis, temperament and composition, as well as volume of the blood in the vertebrate organism. This generalization is amply confirmed by the experimental work on thyroid physiology in mammals. The consequences of extirpation and hypofunction of the gland, and the effects of thyroid feeding and hyperfunction have been the two important phases of the subject to receive intensive study.

Hammett (1923) has shown that when the thyroid is absent, either by developmental aberration as in cretinism, or by design as in experimental extirpation, growth is retarded. Experimental ablation of the thyroid in white rats by the same author (1927a, b) showed that the growth of the heart, lungs, liver, kidney, and spleen was retarded as a result of inadequate thyroid action. Fishburne and Cunningham (1938) observed the same retardation in total growth as a result of thyroidectomy in the white rat. Binswanger (1936) observed that complete ablation of the thyroid in dogs at an early age caused a marked retardation in total growth, and in bone development.

Simpson (1924a and b) observed the same phenomenon in experiments with sheep and goats. Part of this work was based on 16 pairs of twin lambs; one of each pair was thyroidectomized, and the other used as a control. When the operation was performed two or three weeks after birth, marked stunting resulted. In most cases the controls attained a weight of three times that of the experimentals. When thyroidectomy was delayed until the third or fourth month, the retardation in growth was only slight. Essentially the same results were obtained with several pairs of kids. These observations led to the conclusion that conditions comparable to myxoedema can be induced by thyroidectomy in the sheep and goat.

A histological study of the skeletal muscles of the sheep following early thyroidectomy was made by Simpson (1927). The striking results of this study were that normal development in the cytoplasm was prevented, and that the muscle cells resembled those seen normally in very young animals.

A thorough study of the rôle of the thyroid in growth and skeletal maturation in sheep was made by Todd, Wharton, and Todd (1938). The observations were based on five pairs of twin sheep, one of each pair being thyroidectomized in early life (1-5 months), the other serving as a control. Thyroidectomy in early life caused a deficient growth and modelling of the epiphysis, so that when ossification was as fully completed as it would ever be in the defective animals, the epiphysis lacked character, and was inadequate to cap the growing end of the shaft. This inadequacy was particularly evident in the epiphysis of the lower limb bones. There was also a deficiency in growth of the long-bone shafts. The duration of growth was not extended to compensate for the deficiency, but the velocity of growth was diminished so that the finished product was not as perfect as in the controls. This disturbance in growth resulted in producing sheep which had the skeletal proportions of unimproved wild type of animals, having little meat or wool value. Kunde (1926a, b) and Kunde and Williams (1926) found that rabbits and rats after thyroidectomy developed a condition similar to rickets, although they were fed an adequate diet. Xerophthalmia and the lesions of pellagra appeared in the thyroidectomized animals on a diet adequate for controls. Thyroidectomized animals carried through the growth period by thyroid treatment, which was then stopped, developed progressive paralysis starting in the hind

quarters. At autopsy, the animals paralyzed in this manner showed lesions in the spinal cord.

It is beyond all doubt, then, that the normal function of the thyroid is absolutely essential in the early growth and development of mammals. Removal of the thyroid at an early age always results in a stunted individual that is biologically inferior both anatomically and physiologically to the common herd of normal animals. Such stunted individuals, however, can be brought back to a normal state of growth by the administration of some extract of the thyroid gland (Hammett, 1929). Complete recovery by thyroid medication can be obtained only when the deprivation has not permanently impaired the normal physiological processes of growth. An interesting study on the effect of thyroid treatment on the mental and physical growth of cretinous infants was reported by Gesell, Amatruda and Culotta (1936). It was observed that the effects of thyroid substance on the cretinous infant are of three kinds: metabolic, somatic, and neurodevelopmental. An increase in metabolic rate was the most immediate and general effect of the treatment. There was a marked physical improvement in all cases, and in some cases the patients became almost normal. It was found that the final influence of thyroid therapy is contingent not so much on the age of the child, or maturity status at the time of diagnosis, as on the residual physiological capacity and latent growth potency of the neuroendocrine system. Thyroid therapy cannot bring about normality if there has been a fundamental impairment of that system, either hereditary or developmental.

From the above facts on thyroid therapy, as well as from a priori considerations, it is evident that the administra-

tion of thyroid in some form or other to normal animals is a valid method of producing effects similar to those in hyperthyroidism. According to Hammett (1924) such an increase in thyroid activity in an initially normal animal may result in either an acceleration or a retardation in growth processes; the specific effect being entirely dependent upon the size of the dosage. If the dosage is such that anabolism can keep ahead of katabolism, there will be an acceleration in growth. If, on the other hand, the dosage is such that katabolism is predominant, there will be a retardation in growth. With these facts in mind, the apparent inconsistencies in the following studies are clarified.

Gudernatsch (1915) found that thyroid-fed rats did not in a given time reach the length or weight of normal rats. Hewitt (1919) reported that 0.1 gm. or more of fresh thyroid administered daily to adult male white rats produces hypertrophy of the heart, liver, spleen, kidney, and suprarenals, and a diminution in the size of the thyroid gland. Durrant (1928) made a study of the effects of thyroid feeding on guinea pigs, using animals from 7 litters, ranging in age from 12 days to 3 months. The dosage was $\frac{1}{4}$ grain of desiccated thyroid (Armour's) on alternate days for some, and the same amount once a week for others. All the thyroid-fed animals grew less rapidly than their litter controls, and those given the heavier dosage died in from 12 to 20 days. The thyroid-fed showed an increase in weight of 12 percent to 480 percent; the controls, an increase of 75 percent to 675 percent. Robertson (1928) reported that desiccated thyroid tissue administered continuously to white mice in dosages corresponding to 19 mgm. of fresh thyroid per mouse per day accelerated early growth without modifying the maximum

weight which the animals eventually attained. Mean life duration was found to be shortened by thyroid feeding of the above dosage to 15 weeks or 7 percent of the normal life span.

Several physiological phenomena other than metabolism and growth have been shown to be directly affected by thyroid activity. Thus, heart rate, blood composition and blood volume are regulated to a great extent by the thyroid. Fishburne and Cunningham (1938) studying replacement therapy in thyroidectomized rats, found that after removal of the gland the heart rate showed a slight increase (probably due to operation effects) followed by a slowing for several days until it reached a new basal rate of 50 to 100 beats per minute as compared with 300 beats per minute in normal rats. By feeding small amounts of thyroid extract, the heart rate could be raised from the new level to normal or even past the normal level. With thyroxin injections it was found that 0.04 mg. of the crystalline hormone per day raised the heart rate to the normal 300 beats per minute. It was concluded that this amount of thyroxin (0.04) per day is secreted in the rat to maintain a constant heart rate of 300 beats per minute.

Wislicki (1929) reported that in Basedow's disease, where there is an increase in basal metabolism, there is a definite increase in the volume of blood in the body. In contrast, the opposite was found to be the case in myxoedema. In myxoedema, after thyroid medication, the blood volume increases as much as one-and-a-half times that of the original amount.

Blalock and Harrison (1927) studying experimental hyper- and hypothyroidism in dogs showed that cardiac output was increased by the former and decreased by the latter. The percentage change in

cardiac output was usually greater than the change in metabolic rate resulting from the experimental conditions.

Aub (1927) reported that blood calcium and blood phosphorus were normal in thyroid disease, but that the amounts excreted were far above normal. In normal controls thyroid administration raised the blood calcium and increased calcium excretion. In myxoedema the calcium metabolism was found to be lower than normal. In these cases also, thyroid administration caused the blood calcium and calcium excretion to be increased.

The relation of the thyroid to sexual maturation in the mammals is a matter of much controversy. The widely observed fact that thyroid disturbances occur far more frequently among girls and women than among boys and men received further attention in the statistical studies of the subject by Marine and Kimball (1917). That thyroid changes frequently occur in women during changes in ovarian activity (menarche, pregnancy, and menopause) is also a well-known fact. These facts do not, however, lead to the conclusion that the thyroid regulates sexual maturity in an individual, but rather that the sex of the individual in some measure, at least, determines the level of thyroid activity. This fact must be kept well in mind in considering the relation of the thyroid to sex development.

Experimental studies on mammals indicate that the thyroid is in no manner related to the maturation of sex. It will be observed that this conclusion is in accord with Weismann's theory of the independence of the germ cells from the soma.

Hammett (1926) found no relation between thyroid activity and the development of the reproductive system in the white rat. Conditions resulting from

thyroidectomy and thyroid feeding were thought to be secondary to general disturbances in growth, and not specific for the reproductive system.

Da Costa and Carlson (1933) found that 60 female white rats fed 0.5 to 1.0 mg. of desiccated thyroid daily showed a slight acceleration in sexual maturation, while 41 females fed 5.0 to 10.0 mg. daily showed a retardation in sexual development. It is interesting here to note the difference in effect obtained with different doses. The lighter dosage was optimal for anabolism to be predominant, whereas the heavier dosage was conducive to a predominance in katabolism; hence in the former case there was an acceleration in total development (including sexual maturation) and in the latter, there was a general retardation. Males fed 0.5 to 1.0 mg. of the above-mentioned extract showed lighter testis weight than controls, even when the body weight of experimentals was greater than that of the controls. The same held true for 5.0 and 10.0 mg. daily fed to males.

The secretion of milk and of milk fat in mammals is undoubtedly under the regulation of the thyroid gland. The effect of thyroid feeding and thyroxin injections on the secretion of milk and on milk fat production in cows was discussed by Graham (1934a and 1934b). In the former paper, this worker reported that the addition of small amounts of thyroid to the diet of normal cows, when the curve of lactation was falling, caused a rapid rise in milk and milk fat production for a short time, after which the curve continued to follow the original declining trend. During the period of rising milk secretion which continues for some 4 to 6 weeks after parturition, thyroid feeding had no apparent effect on the amount of milk secreted. The conclusion was drawn that there is a relationship between total

metabolic rate and the secretion of milk and milk fat; the secretion being greater with a faster rate of metabolism. In the second study (1934b) Graham showed that thyroxin is the principle in the thyroid gland which causes a marked increase in the production of milk fat in cows. The rise in milk secretion following thyroxin injections showed large variations, giving evidence that the cause of the increase in total milk secretion may not be identical with cause of the rise in milk fat. Folley and White (1936) confirmed the work of Graham by showing that daily injections of thyroxin into cows in declining lactation increased the milk flow as well as the production of milk fat and non-fatty solids.

The effect of hyperthyroidism on the hair of mammals has also been studied by several workers. Zawadovsky (1926) found that thyroid feeding of dogs and guinea pigs causes a marked loss of hair, but with no apparent blanching of colors.

Chang (1926) reported that albino rats deprived of the thyroid gland showed a retardation of hair growth. Upon feeding suitable amounts of thyroid (0.5 to 0.7 g.) in doses of 0.03 g. per day, the hair grew normally. Undernourished animals with intact thyroids showed a similar retardation of hair growth. Thyroid fed to such animals kept on a starvation diet improved hair growth in spite of the further decreased body weight caused by excessive katabolism in addition to the originally deficient anabolism. These observations led to the conclusion that the thyroid has a specific influence on the growth of hair.

Sainton and Simonnet (1931) made a number of interesting observations on the influence of the thyroid on hair characteristics. In a clinical case of Basedow's disease, premature white hair was observed in members of three previous generations. In another case, a father and

four sons having a malady similar to exophthalmic goitre showed premature yet complete gray hair at the age of 30 or under. In another case where the father had gray hair before 30, his daughter and granddaughter showed early signs of Basedow's disease. In several cases premature gray hair was observed in both the father and mother of hyperthyroid subjects. In another case Basedow's disease resulted in premature gray hair in patches in two brothers whose hair was noticeably scanty. The last case reported was that of a mother who had Basedow's disease, and her son and daughter were observed to have the disease at the age of 15 to 20. These observations indicated to the investigators that not only is the thyroid related to hair character, *but that phaenotypic changes acquired by hyperthyroidism are hereditary.* The experimental work on hyperthyroidism of birds and mammals indicate that it is not strange for gray hair and Basedow's disease to exist in ascendants and descendants, as observed in the clinical data. The conclusion is made that in all such cases as noted above, hyperthyroidism surely exists though its manifestations may present themselves in either the clinically typical form, or instead be only of a monosymptomatic nature, such as premature gray hair. In any event the hyperthyroid reaction appears to be transmitted to the progeny of affected subjects, the mode of transmission, however, remaining obscure.

Cockayne (1928) made a study of the influence of heredity on exophthalmic goitre. His observations were based on carefully prepared family histories. The obvious conclusion reached was that since the disease is so rarely present at birth, so variable in its date of onset, and so often transmitted by apparently healthy parents, it is more easily explained on the

basis of an inherited constitutional weakness of the thyroid gland rather than of the inheritance of Graves' disease itself. The constitutional weakness appears to be inherited as a dominant, and some of those who inherit it may remain apparently healthy while others may develop any of the manifestations of the disease under the influence of injurious geographical influences.

Several experimental studies have been made on the inheritance of thyroid effects. Marza and Marza (1929) found a slight reduction in the weight of the thyroid glands of guinea pigs of thyroidectomized parents. Histologically, the differentiation of the cells of the gland was greatly retarded. Marza-Rusnac (1929) confirming the earlier work, reported that thyroidectomy in guinea pigs resulted in a decrease in size and weight of the thyroid gland of the new-born. The offspring of the thyroidectomized animals were definitely smaller and weaker at birth than the controls.

The relation of the thyroid function to temperament has studied by Brown and Gildea (1927). These investigators showed, on the basis of 15 cases, that there is a constitutional predisposition to hyperthyroidism, implying a sensitive thyroid gland as indicated by the high incidence of nervous irritability among relatives. Persons who are constitutionally so predisposed were found to have a feeling of personal insecurity, a strong sense of responsibility and a tendency to turn the effects of their emotional experiences within rather than give them outward expression, that is, to be typical introverts.

Studies on the normal function of the mammalian thyroid show conclusively that the gland is essential in the regulation of metamorphosis, growth, metabo-

lism, hair growth, blood volume and composition, milk secretion, and even of temperamental characters. Thyroid feeding will cause an acceleration in the developmental processes, and naturally an increase in volume of the product developed; this, however, only so long as anabolism remains predominant. When the dosage is of such size that extreme hyperthyroidism sets in, with its accompanying predominance in katabolism, apparently anything can happen, the ultimate result usually being the death of the organism. The failure of the early workers to state the dosage of thyroid used in experimental feeding, and the failure of many of the later ones to determine the effect of a logically planned *range* of dosages have only tended to confuse the question of thyroid activity and to increase the ambiguity of experimental results and conclusions.

The above review of studies on the thyroid feeding of vertebrates brings several interesting facts to light. The first is that the vertebrate thyroid, which normally is an organ of internal secretion, delivering its product to the body par-enterally, may, if eaten (which is to say, put into the body by the enteral route) induce definite and considerable changes in the physiology of the organism both immediately and over considerable periods of time. The second is that these changes, which are seen as accelerations of metamorphosis in amphibians, or of either the moulting cycle of feather production in birds, or of growth or of milk or milk fat secretion in mammals, are all manifestations or expressions of the metabolic regulator function of the gland which is its basic job.

(To be concluded)



SPECIES SPECIFICITY OF THE GONADOTROPIC FACTORS IN VERTEBRATES

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MOST recent studies concerned with the pituitary secretions have revealed increasingly frequent reference to the factor of species variation in the elucidation of certain of the data. In 1929 Houssay found that pituitary implants from different vertebrate classes could not duplicate the phenomenon of ovulation induction as it was produced in the toad by homoplastic implants. He was probably the first to advance the hypothesis of gonadotropic hormone species specificity as a basis for the interpretation of these results. Since that time it has become definitely established that there is a variation in *quantity* of the anterior pituitary hormones from species to species. This fact has been sufficient to explain many cases of apparent irregularities in response, or in dosage required to produce a given response. In some cases, however, and especially those cases in which the hormone donor and recipient are of widely divergent taxonomic types, it becomes clear that a *qualitative* variation in the hormones, like that postulated by Houssay, must be given consideration. Such a conception represents an advance over the general opinion held by endocrinologists a few years ago as summarized by P. E. Smith (1932) "A species specificity either in a hormone or in the receptivity

to a hormone is contrary to the current concept of hormonal physiology."

Since 1929 numerous instances of refractoriness of animals to pituitary hormones of extra-specific origin have been presented in the literature of endocrinology, and these have been explained in various ways. The possibility of hormone species specificity has often been proposed, but almost never systematically tested. In 1935 Creaser and Gorbman (1935, 1936) examined the refractoriness of the common leopard frog, *Rana pipiens*, to large doses of mammalian gonadotropic materials, in contrast to its ready response to homoplastic treatment or treatment with pituitaries from closely related species. They concluded after elimination of all factors, excepting those characteristic and common to the number of actual hormone mixtures tested, that a gonadotropic hormone species specificity has been demonstrated. The discovery of antihormones by Collip and Anderson (1934) directed considerable attention to the question of pituitary hormone species specificity inasmuch as a number of investigators have claimed that antihormones are merely antibodies formed in response to immunologically distinct, and therefore species specific, hormones.

The implication of hormone specificity in cases of chronic injection of anterior

pituitary substances, and the possible clinical significance of this specificity factor in the general ineffectiveness of animal pituitary extracts in humans indicate that hormone variation even between more closely related vertebrates may be of more than academic importance. Furthermore, to those who are impressed by the factor of species variation it seems that the validity of comparing values obtained in bioassay of different pituitary hormone preparations becomes liable to considerable doubt. Since a summarization of the data bearing upon pituitary hormone species specificity seems particularly valuable at the present time, it is proposed to include here such a review, as well as an amplification of some previous work on this problem with amphibia. The present consideration will be confined to the gonadotropic factors since these are the only ones which have been studied generally enough to allow comparisons.

Ample study by chemists has shown that the gonadotropic hormones cannot be disassociated from certain typical protein properties. In other words, these hormones are proteins, or are parts of stable protein complexes. This fact requires almost *a priori* that a species specificity exists in the hormone since it would be extremely unusual to find the hormone property associated with the same protein in more than one species. The task which must occupy the attention of those investigating this question is the determination of the physiological significance of such interspecific variation. The most direct method which suggests itself is the exchange of hormones between species to test the ability of these substances to produce their usual effects in other animal types.

It is unfortunate that much of the data of the most generally studied anterior pituitary factors, the gonadotropic hor-

mones, cannot be clearly evaluated. Although some endocrinologists still point out that the existence of more than one hypophyseal gonadotropic hormone has not been absolutely demonstrated, it seems quite definitely established at the present time that different fractions may be obtained from the pituitary which affect different phases of gonadal activity. Thus, follicle-stimulating, lutein-stimulating, interstitial cell-stimulating, gonadotropic antagonist, and even other gonadotropic principles have been reported. Just as different threshold values may exist in different animals to the same pharmaceutical reagent, and varying proportions of reacting tissues may be present in the affected organs of different species, there must manifestly be a variety of reactions yielded by a number of test animal species treated with a given gonadotropic mixture. If variability between animal species in type and degree of reaction to gonadotropic hormones could be ascribed entirely to this quantitative variability in gonadotropic fractions, and test gonad threshold sensitivity, it could be construed that the species specificity is of negligible importance. This is no doubt largely correct in the interpretation of results from hormone exchanges between more closely related vertebrates, but as previously intimated, results of hormone exchanges between phylogenetically distant species cannot be successfully explained on a quantitative basis.

AMPHIBIA

Experiments with mammalian hypophyseal extracts in amphibia have furnished a fairly complete body of data indicating that qualitative hormone variation between these two classes is of sufficient value to reduce remarkably the efficiency of action of the hormones in reciprocal exchange. Apparently ovula-

tion is the only reaction of which the mature amphibian ovary, used in such experiments, is capable in order to indicate overtly the efficacy of the particular gonadotropic agent tested. Some amphibians are entirely refractory to large dosages of mammalian gonadotropic preparations of any kind. The high dosages administered and the variety of preparations used obviate almost any explanation of these facts on the basis of high threshold, or absence of the correct gonadotropic fraction to produce ovulation. The inadequacy of the threshold hypothesis may also be indicated from the fact that treatment with a very small amount of homoplastic pituitary material will invariably stimulate ovulation. That a substance is present in the experimentally ineffective extracts which is at least comparable to the amphibian ovulation-inducing factor, is seen in experiments with certain species of amphibians which can be made to ovulate with large doses of mammalian gonadotropic preparations. Of considerable interest in this regard are the corroborative experiments now being made by several investigators in which efforts are being made to ovulate *Rana pipiens* with large quantities of gonadotropic materials of mammalian origin. While these experiments have not been completed, we are permitted to say that even with large quantities of fresh mammalian material no ovulation has been produced. Recent work by Mayo (1937), reported in abstract, in which FSH and LH preparations (after Fevold's procedure) from sheep pituitary were tested in *Triturus viridescens*, indicates that ovulation may be stimulated by LH, and growth of the spent ovary proceeds more rapidly under the influence of repeated FSH injections than LH injections. However, in both cases ovary restoration was greater than in untreated animals.

Table I is a summary of the data which have been accumulated in work with the amphibians as test animals. This table reveals the fact that the reactivity of amphibians in general varies from complete refractoriness to relatively ready responsiveness to mammalian gonadotropic preparations. Those amphibians in which a response is produced by mammalian preparations require very large doses. One of the more sensitive amphibians, *Xenopus laevis*, which has been described as suitable for a pregnancy test (Bellerby, 1934; Shapiro and Zwarenstein, 1934), is treated with more than 1000 rat units of prolactin to induce ovulation (calculated by Witschi, 1937, after data of Shapiro and Zwarenstein). On the other hand, all amphibian species which have been treated with homoplastic pituitary, including those which are completely refractory to mammalian pituitary, respond readily to a few milligrams of homoplastic tissue. We have found that dosages as high as 1700 rat units of prolactin, 110 rat units of beef pituitary extract, 6.6 cc. of a crude extract of sheep pituitary, or 7.2 cc. of pregnant mare's serum extract (all extracts were Parke Davis & Company products) will not induce extra-seasonal ovulation in *Rana pipiens*. If some of the frogs which yielded these negative results were implanted with homoplastic pituitaries after a suitable interval, ovulation occurred after treatment with as few as two or three glands (about 5 milligrams of fresh tissue). Rarely was it necessary to use as many as eight or nine pituitaries. The ovary of *Rana pipiens* is also responsive to implants of hypophyses of other Anura (*Rana clamitans*, *Rana catesbeiana*, *Rana sphenoccephala*, *Bufo marinus*, *Triturus viridescens*), but when considerable amounts of pituitaries of fish are used (perch, lake trout, wall-eye pike, dog shark) the same responsiveness can no

TABLE I

| RECIPIENT | SOURCE OF PREPARATION | NATURE OF PREPARATION | RESULT | AUTHORITY | REMARKS |
|----------------------------|--|---|--------|---|--|
| <i>Ambystoma tigrinum</i> | 1 Sheep pituitary | 1 Extract | 1 + | 1 Barth, Burns and Buyse 2 Voss | |
| | 2 Beef (?) pituitary | 2 Schering and Kahlbaum thyrotropic extract | 2 + | | |
| | 3 Human pregn. urine | 3 Extract | 3 + | 3 Barth, Ogilvie | |
| <i>Bombinator pachypus</i> | 1 <i>Bombinator pachypus</i> | 1 Fresh implants | 1 + | (1-9) Moskowska | In 1 to 8 mixtures of several species used in some cases |
| | 2 <i>Bombinator igneus</i> | 2 Fresh implants | 2 + | | |
| | 3 <i>Bufo viridis</i> | 3 Fresh implants | 3 + | | |
| | 4 <i>Bufo vulgaris</i> | 4 Fresh implants | 4 + | | |
| | 5 <i>Alytes obstetricans</i> | 5 Fresh implants | 5 + | | |
| | 6 <i>Rana tschulensis</i> | 6 Fresh implants | 6 + | | |
| | 7 <i>Rana temporaria</i> | 7 Fresh implants | 7 + | | |
| | 8 <i>Triton cristatus</i> | 8 Fresh implants | 8 + | | |
| | 9 Beef | 9 Alkaline extract | 9 - | | |
| <i>Bufo americanus</i> | 1 <i>Rana pipiens</i> | 1 Fresh implants | 1 - | 1 Bardeen 2 Wills, Riley, and Scrubbs 3 Wills, Riley, and Scrubbs 4 Wills, Riley, and Scrubbs 5 Kuyper Pfeiffer and Wills | Negative result in 1 may be due to diseased animals |
| | 2 <i>R. pipiens</i> plus <i>R. sphenocephala</i> | 2 Fresh implants | 2 + | | |
| | 3 <i>Lepidosteus</i> | 3 Fresh implants | 3 + | | |
| | 4 Albino mouse | 4 Fresh implants | 4 - | | |
| | 5 Human pregn. urine | 5 Extract | 5 - | | |
| <i>Bufo arenarum</i> | 1 <i>Bufo arenarum</i> | 1 Fresh implants | 1 + | 1 Houssay 2 Novelli 3 Houssay 4 Houssay, Novelli 5 to 13, Houssay <i>et al.</i> | |
| | 2 <i>Bufo arenarum</i> | 2 Desiccated powder | 2 + | | |
| | 3 <i>Bufo d'ariganyi</i> | 3 Fresh implants | 3 + | | |
| | 4 <i>Lepidosteus ocellatus</i> | 4 Fresh implants | 4 + | | |
| | 5 <i>Micropterus</i> (fish) | 5 Fresh implants | 5 - | | |
| | 6 <i>Xenodon</i> (snake) | 6 Fresh implants | 6 - | | |
| | 7 <i>Gallus</i> (hen) | 7 Fresh implants | 7 - | | |
| | 8 White rat | 8 Fresh implants | 8 - | | |
| | 9 Guinea pig | 9 Fresh implants | 9 - | | |
| | 10 Dog | 10 Fresh implants | 10 - | | |
| | 11 Beef | 11 Fresh implants | 11 - | | |
| | 12 Beef | 12 Acid or alk. extract | 12 - | | |
| | 13 Human pregn. urine | 13 Extract | 13 - | | |

| <i>Bufo calamita</i> | 1 Ox 2 Human pregn. urine | 1 Extract 2 Extract | 1 — 2 — | 1 and 2, Cunningham and Smart | |
|-----------------------------------|--|---|---|-----------------------------------|------------------------------------|
| <i>Bufo d'arbigyi</i> | 1 <i>Bufo d'arbigyi</i> 2 <i>Bufo ornatum</i> 3 <i>Lepidactylus ocellatus</i> | 1 Fresh implants 2 Fresh implants 3 Fresh implants | 1 + 2 + 3 + | 1 to 3, Houssay | |
| <i>Bufo fowleri</i> | 1 <i>Bufo fowleri</i> 2 <i>Rana catesbeiana</i> 3 <i>Rana clamitans</i> 4 <i>Rana palustris</i> 5 <i>Rana pipiens</i> 6 Sheep 7 Human pregn. urine | 1 Fresh implants 2 Fresh implants 3 Fresh implants 4 Fresh implants 5 Fresh implants 6 Extract 7 Extract | 1 + 2 + 3 + 4 + 5 + 6 + 7 + | 1 to 7, Rugh | |
| <i>Bufo vulgaris</i> | 1 <i>Bufo vulgaris</i> 2 <i>Rana vulgaris</i> 3 Rabbit 4 Beef 5 Beef 6 Human pregn. urine 7 Same as 5 and 6 | 1 Fresh implants 2 Fresh implants 3 Fresh implants 4 Fresh implants 5 Alkaline extract 6 Extract 7 Combined 5 and 6 | 1 + 2 — 3 — 4 — 5 — 6 — 7 — | 1 Adams, Rostand 2 to 7, Adams | |
| <i>Desmognathus fusus</i> | 1 <i>Rana pipiens</i> 2 <i>R. pipiens</i> plus <i>Gyrinophilus</i> 3 Beef | 1 Fresh implants 2 Fresh implants 3 Alkaline extract | 1 + 2 + 3 + | 1 and 2, Noble and Evans | No apparent gonad response in male |
| <i>Desmognathus pictus</i> | 1 Beef | 1 Alkaline extract | 1 + | 1 Kehl | |
| <i>Eurycea bilineata</i> | 1 <i>Eurycea bilineata</i> | 1 Fresh implants | 1 + | 1 Noble and Richards | No apparent response in male |
| <i>Gyrinophilus porphyriticus</i> | 1 <i>Rana pipiens</i> | 1 Fresh implants | 1 + | 1 Noble and Richards | No apparent response in male |

TABLE I—Continued

| RECIPIENT | SOURCE OF PREPARATION | NATURE OF PREPARATION | RESULT | AUTHORITY | REMARKS |
|--------------------------------|---|--|---|---|------------------------------|
| <i>Hyla aspera</i> | 1 Pregnant mare serum | 1 Extract | 1 + | 1 Creaser and Gorbman | |
| <i>Leptodactylus ocellatus</i> | 1 <i>L. ocellatus</i> 2 <i>Bufo arenarum</i> 3 <i>Bufo d'arbigyi</i> 4 Beef | 1 Fresh implants 2 Fresh implants 3 Fresh implants 4 Alkaline extract | 1 + 2 + 3 + 4 — | 1 Houssay 2 Houssay, Novelli 3 Houssay 4 Novelli | |
| <i>Pseudobombus strabus</i> | 1 (Probably <i>Rana pipiens</i>) pituitary | 1 Fresh implants | 1 + | 1 Noble and Richards | No apparent response in male |
| <i>Rana aspera</i> | 1 <i>Rana aspera</i> | 1 Fresh implants | 1 + | 1 Creaser and Gorbman | |
| <i>Rana catribeliana</i> | 1 <i>Rana clamitans</i> 2 <i>Rana pipiens</i> 3 Sheep 4 Human pregn. urine | 1 Fresh implants 2 Fresh implants 3 Extract 4 Extract | 1 + 2 + 3 — 4 + | 1 to 4, Rugh | |
| <i>Rana clamitans</i> | 1 <i>Rana clamitans</i> 2 <i>Rana catribeliana</i> 3 <i>Rana palustris</i> 4 <i>Rana pipiens</i> 5 <i>Bufo fowleri</i> 6 Sheep 7 Human pregn. urine | 1 Fresh implants 2 Fresh implants 3 Fresh implants 4 Fresh implants 5 Fresh implants 6 Extract 7 Extract | 1 + 2 + 3 + 4 + 5 + 6 — 7 — | 1 to 7, Rugh | |
| <i>Rana esculenta</i> | 1 <i>Rana esculenta</i> 2 <i>Rana temporaria</i> 3 Carp 4 Whiting 5 Green lizard (<i>Lacerta viridis?</i>) 6 Chicken 7 Beef | 1 Fresh implants 2 Fresh implants 3 Fresh implants 4 Fresh implants 5 Fresh implants 6 Fresh implants 7 Fresh implants | 1 + 2 + 3 — 4 — 5 — 6 — 7 — | 1 to 8, Rostand | |

| | | | | | |
|----------------------------------|--------------------------------|-------------------|------|---|--|
| <i>Rana esculenta</i> — Cont. | 8 (Beef) | 8 Extract | 8 — | 9 Cunningham and Smart | Treatment started too soon after laying season. + result in a later experiment |
| | 9 Ox | 9 Acid extract | 9 — | 10 Cunningham and Smart, Rostand | |
| | 10 Human pregn. urine | 10 Extract | 10 — | 11 Rostand | |
| | 11 Egg laying frog urine | 11 — | 11 — | | |
| <i>Rana japonica</i> | 1 <i>Rana nigricauda</i> | 1 Fresh implants | 1 + | 1 Osima | |
| <i>Rana nigricauda</i> | 1 <i>Rana nigricauda</i> | 1 Fresh implants | 1 + | 1 Osima | |
| <i>Rana palustris</i> | 1 <i>Rana palustris</i> | 1 Fresh implants | 1 — | 1 to 6, Rugh | Treatment started too soon after laying season. + result in a later experiment |
| | 2 <i>Rana catesbeiana</i> | 2 Fresh implants | 2 — | | |
| | 3 <i>Rana clamitans</i> | 3 Fresh implants | 3 — | | |
| | 4 <i>Rana pipiens</i> | 4 Fresh implants | 4 + | | |
| | 5 <i>Bufo fowleri</i> | 5 Fresh implants | 5 — | | |
| | 6 Sheep | 6 Extract | 6 — | | |
| <i>Rana pipiens</i> | 1 <i>Rana pipiens</i> | 1 Fresh implants | 1 + | 1 Bardeen, Barth, Creaser and Gorbman, Rugh, Wolf | 16 to 20 too soon after normal laying season |
| | 2 <i>Rana catesbeiana</i> | 2 Fresh implants | 2 + | 2 Creaser and Gorbman | |
| | 3 <i>Rana clamitans</i> | 3 Fresh implants | 3 + | 3 Creaser and Gorbman | |
| | 4 <i>Rana iphinocephala</i> | 4 Fresh implants | 4 + | 4 Creaser and Gorbman | |
| | 5 <i>Bufo marinus</i> | 5 Fresh implants | 5 + | 5 Creaser and Gorbman | |
| | 6 <i>Necturus maculosus</i> | 6 Fresh implants | 6 — | 6 Creaser and Shcolnick | |
| | 7 <i>Lepidosteus</i> | 7 Fresh implants | 7 + | 7 Wills, Riley, and Stubbs | |
| | 8 <i>Cristomer namaycush</i> | 8 Fresh implants | 8 — | 8 Creaser and Gorbman | |
| | 9 <i>Perc flavescens</i> | 9 Fresh implants | 9 — | 9 Creaser and Gorbman | |
| | 10 <i>Stizostedion vitreum</i> | 10 Fresh implants | 10 — | 10 Creaser and Gorbman | |
| | 11 <i>Squalus suckleyi</i> | 11 Fresh implants | 11 — | 11 Creaser and Gorbman | |
| | 12 Sheep | 12 Extract | 12 — | 12 Barth, Creaser and Gorbman, Rugh | |
| | 13 Beef | 13 Extract | 13 — | 13 Creaser and Gorbman | |
| | 14 Pregnant mare serum | 14 Extract | 14 — | 14 Creaser and Gorbman | |
| | 15 Human pregn. urine | 15 Extract | 15 — | 15 Barth, Creaser and Gorbman, Rugh | |
| | 16 <i>Rana catesbeiana</i> | 16 Fresh implants | 16 — | 16 Rugh | |
| | 17 <i>Rana clamitans</i> | 17 Fresh implants | 17 — | 17 Rugh | |
| | 18 <i>Rana palustris</i> | 18 Fresh implants | 18 — | 18 Rugh | |
| | 19 <i>Rana pipiens</i> | 19 Fresh implants | 19 — | 19 Rugh | |
| | 20 <i>Bufo fowleri</i> | 20 Fresh implants | 20 — | 20 Rugh | |

TABLE I—*Continued*

| RECIPIENT | SOURCE OF PREPARATION | NATURE OF PREPARATION | RESULT | AUTHORITY | REMARKS |
|-----------------------------|---|-------------------------|--------|---|------------------------------|
| <i>Rana temporaria</i> | 1 <i>Rana temporaria</i> | 1 Fresh implants | 1 + | 1 Rostand | |
| | 2 <i>Rana esculenta</i> | 2 Fresh implants | 2 + | 2 Rostand | |
| | 3 Carp | 3 Fresh implants | 3 — | 3 Rostand | |
| | 4 Whiting | 4 Fresh implants | 4 — | 4 Rostand | |
| | 5 Green lizard | 5 Fresh implants | 5 — | 5 Rostand | |
| | 6 Chicken | 6 Fresh implants | 6 — | 6 Rostand | |
| | 7 Ox | 7 Acid extract | 7 + | 7 Cunningham and Smart | |
| | 8 Beef | 8 Fresh macerated | 8 + | 8 Bellerby, Gallien | |
| | 9 Beef | 9 Fresh macerated | 9 — | 9 Rostand | |
| | 10 Beef | 10 Acid or alk. extract | 10 + | 10 Bellerby, Gallien, Ponce | |
| | 11 Beef (?) | 11 Extract | 11 — | 11 Rostand | |
| | 12 Beef | 12 Desiccated powder | 12 ± | 12 Gallien | |
| | 13 Human pregn. urine | 13 Extract | 13 — | 13 Cunningham and Smart, Gallien, Rostand | |
| | 14 Castrate urine | 14 Extract | 14 — | 14 Gallien | |
| | 15 Same as 13 and 14 | 15 Combined 13 and 14 | 15 — | 15 Gallien | |
| | 16 Egg laying frog urine | 16 | 16 — | 16 Rostand | |
| <i>Rana vulgaris</i> | 1 <i>Rana vulgaris</i> | 1 Fresh implants | 1 + | 1 to 5, Adams | |
| | 2 <i>Bufo vulgaris</i> | 2 Fresh implants | 2 + | | |
| | 3 Beef | 3 Alkaline extract | 3 + | | |
| | 4 Human placenta | 4 Acid extract | 4 — | | |
| | 5 Human pregn. urine | 5 Extract | 5 — | | |
| <i>Rhyacionia olivaceus</i> | 1 <i>Dermoglyphus</i> , <i>Eurycea</i> and <i>R. catibitana</i> | 1 Fresh implants, mixed | 1 + | 1 Noble and Richards | No apparent response in male |
| | 1 <i>Rana pipiens</i> | 1 Fresh implants | 1 + | 1 Noble and Richards | |
| <i>Triton cristatus</i> | 1 <i>Triton cristatus</i> | 1 Fresh implants | 1 + | 1 Adams; Noble and Richards | |
| | 2 <i>Rana pipiens</i> | 2 Fresh implants | 2 + | 2 Adams | |

| | | | | |
|--|---|--|--|--|
| <i>Triturus pyrbogaster</i> | 1 <i>T. pyrbogaster</i> 2 <i>Rana catesbeiana</i> 3 <i>Rana pipiens</i> 4 Sheep pituitary 5 Human pregn. urine | 1 Fresh implants 2 Fresh implants 3 Fresh implants 4 Extract 5 Extract | 1 + 2 + 3 + 4 + 5 + | 1 Barth 2 Creaser and Gorbman 3 Barth 4 Creaser and Gorbman 5 Barth, Creaser and Gorbman, Ogilvie |
| <i>Triturus torosus</i> , <i>T. similans</i> , <i>T. rivularis</i> | 1 <i>Triturus torosus</i> , <i>T. similans</i> , <i>T. rivularis</i> 2 Bull pituitary 3 Turkey pituitary 4 Pregnant mare serum | 1 Fresh implants 2 Extract 3 Extract 4 Extract | 1 + 2 + 3 + 4 - | 1 Twitty, Witschi 2 Witschi 3 Witschi 4 Witschi |
| <i>Triturus viridescens</i> | 1 <i>T. viridescens</i> 2 <i>Bufo terrestris</i> 3 <i>Rana pipiens</i> 4 Rooster or chick 5 Beef 6 Beef 7 Sheep 8 Human pregn. urine | 1 Fresh implants 2 Fresh implants 3 Fresh implants 4 Implant or powder 5 Extract (phyone) 6 Extract 7 Extract 8 Extract | 1 + 2 + 3 + 4 + 5 + 6 - 7 - 8 + | 1 Adams, Barth, Morgan and Sondheim, Stein, Noble and Richards 2 Adams 3 Adams, Barth, Dawson and Jiminez, Lipsett and Platt 4 Stein 5 Adams 6 Dawson and Jiminez 7 Dawson and Jiminez 8 Adams, Barth |
| <i>Xenopus laevis</i> | 1 Beef 2 Ox 3 Human pregn. urine | 1 Acid or alk. extract 2 Extract 3 Extract | 1 + 2 + 3 + | 1 Bellerby, Shapiro 2 Cunningham and Smart, Hogben 3 Bellerby, Cunningham and Smart, Shapiro and Zwarenstein |

longer be demonstrated. As a matter of fact, recent work in this laboratory (Creaser and Shcolnek, 1939) shows that *Rana pipiens* will not respond by ovulation to doses of eighteen pituitaries of the urodele amphibian *Necturus maculosus*. Adams and Granger (1938a) have induced ovulation in *Rana pipiens* with from 40 to 90 glands obtained from *Triturus viridescens*. The only report of induced ovulation in *Rana pipiens* with fresh pituitary of a fish, *Lepisosteus* (garp-ike), was obtained in a single specimen treated by Wills, Riley, and Stubbs (1933b) who mention no control specimens. This report now seems rather doubtful and in need of checking in view of our negative results with five species of fish and with *Necturus*.

The male of *Rana pipiens* is far more sensitive to gonad stimulation than the female, and we have avoided a presentation of data from such animals in order to obviate misleading positive results. If placed in the presence of a female which has been stimulated by implants to ovulate out of season an untreated male *Rana pipiens* will almost invariably perform amplexus and will shed spermatozoa to fertilize released eggs. In contrast to most amphibia, viable spermatozoa may be obtained by testis maceration any time of the year from healthy males. It is also true of this species that the nuptial thumb pads remain large during the whole year, although they do grow even larger during the breeding season. Most other frogs during the non-breeding period have the thumb pads so reduced in size as to make it impossible to distinguish the hand of the male from the female. Wolf (1937) has reported shedding of sperm in isolated male *Rana pipiens* in response to frog pituitary implants, also to extracts of sheep and horse pituitary and pregnant mare's serum. In contrast with the un-

usual case of *Rana pipiens*, Houssay, Giusti, and Gonzalez (1929), Noble and Evans (1932), and Noble and Richards (1930a, 1930b, 1932) have described a number of cases in Amphibia in which stimulation of the male gonad proved more difficult than stimulation of the ovary.

Analysis of Table I furnishes at least one more important generalization concerning gonadotropic species specificity. It can be seen that whereas the responsiveness of any single species listed here can vary greatly, the limiting factor within the scale of responsiveness of the species in question is one of phylogenetic relation between donor and recipient of hormone. Since, with the possible though questionable exception of the datum of *Lepisosteus* pituitary in *Rana pipiens*, there is not a single exception to this generalization derived from the compiled work of so many investigators working with so many species, it should be granted considerable weight.

The apparently contradictory negative data of Rostand (1934) with fish, lizard, chicken, and beef material in the frog *Rana temporaria* are probably due to insufficient dosage, and cannot be granted any significance in view of their disagreement with the positive results of four other investigators with cattle pituitary preparations in this same test animal. On the one hand there are such resistant species as typified by *Bufo vulgaris* which will respond to homoplastic implants, but not to the pituitaries of another anuran, *Rana vulgaris*, or to considerable amounts of mammalian gonad stimulating preparations (Adams, 1931a). At the other extreme there are forms like *Triturus pyrrhogaster*, *Triturus viridescens* (Adams, 1930a, 1930b, 1931b, 1938), and *Bufo fowleri* (Rugh, 1935a), which, as reported, will respond to mammalian as well as to am-

phibian gonadotropins, although here too the phylogenetic limiting factor expresses itself in the extraordinary inefficiency of the mammalian substance in eliciting the same response ordinarily produced by a very small amount of homoplastic pituitary tissue. In our experience with *Triturus pyrrhogaster* fully ripe females respond quite regularly to a minimum of 100 to 120 rat units of prolactin injected over a period of five to seven days, but will readily respond in a shorter time to 2 to 4 homoplastic implants, or even to a single adult *Rana catesbeiana* pituitary. Intermediate in responsiveness to extra-specific pituitary are *Bufo arenarum* which responds to homoplastic pituitaries and those of other Anura, but not to fish, reptile, bird, or mammal pituitary (Houssey *et al.*, 1929b); *Bufo americanus*, which responds to frog and fish pituitary but not to mammalian preparations (Kuyper *et al.*, 1933; Wills *et al.*, 1933a, 1933b); *Rana temporaria* and *Rana vulgaris* which respond to frog pituitary and certain mammalian preparations, but not others (Rostand, 1934; Gallien, 1937; Adams, 1931a). This apparent dependence of gonadotropic efficiency upon taxonomic relationships between hormone host and recipient rather than on the nature of the gonadotropic preparation indicates that species variation may be quite significant. This same phenomenon considered together with the variety of mammalian preparations which will produce ovulation in some Amphibia further indicate that perhaps several mammalian gonadotropic fractions can stimulate the same gonadal activity in amphibians, namely ovulation. As has been pointed out by Witschi (1937), this may be of some significance in the question of the evolution of separate gonadotropic factors in specialized vertebrates and should receive attention in future work with less specialized forms.

Treatment of mammals with amphibian pituitary has not been notably effective. Lipschütz and Pacz (1928) found that doses of as many as 12 pituitaries of the large Chilean frog, *Calyptocephalus*, produced no gonad stimulation in the mouse. Similarly, Adams and Tukey (1937) reported that very large doses of leopard frog pituitary (16 to 96 glands) were without gonad stimulating action in the mouse. Zwarenstein (1937), however, reported that doses of South African clawed frog (*Xenopus laevis*) pituitary as high as 20 milligrams, implanted in immature mice, produced signs of ovary stimulation in opening of the vagina in ten out of twelve animals, increase in weight of the uterus, and *Blutpunkte* in both ovaries of two specimens, although no significant weight increase was noted in the stimulated gonads. Adams and Granger (1938b) have also reported ovary stimulation with amphibian pituitary (*R. pipiens*) in the mammal. They obtained increased weights in the uterus and vagina of the immature female test mice and histological evidence of ovary stimulation, but not a very marked increase in ovary weight. Using the immature rat as test animal, Benazzi (1937) has reported failure to produce gonad stimulation with anterior pituitary implants of a frog, *Discoglossus pictus*, or of the axolotl, *Ambystoma tigrinum*. Del Castillo and Novelli (1938) in a different type of experiment, found that combination of 5 pituitaries of the toad, *Bufo arenarum*, with prolactin injections produced a significant increase in the weights of ovaries in the rat over the weights produced by prolactin alone. It is difficult to generalize from such an incomplete series of data, but it does seem that higher doses of amphibian pituitary may be expected to exert a gonadotropic effect in mammals, in the same manner that high doses of mammalian prepara-

tions affect the amphibian gonad. Perhaps a mammal may be found with a more responsive gonad than the rat or the mouse, which will lend itself more readily to such experiments, and which might provide a more sensitive assay method for mammalian gonadotropic materials.

BIRDS

Although birds have been the subjects of extensive pituitary research, too few species have been studied, and too many different criteria of gonadotropic hormone activity have been utilized to permit a comparison like that made for the amphibia. In view of the striking difference in the sensitivity of birds to different mammalian gonadotropic fractions discussed by Evans and Simpson (1934), Breneman (1936), Domm (1937), and Witschi (1937), it would be hazardous to generalize from the few cases at hand. There is not only a large variation in gonad sensitivity between species of birds, but also a differential sensitivity between sexes in fowl, pigeons, and ducks. Age is also a basic factor, not only in the general sensitivity of the gonad, but also in its differential sensitivity to the various gonadotropic fractions. These facts appear in the work of Asmundson and Wolfe (1935), Breneman (1936), Domm and Van Dyke (1932), Krizenecky and Kamenicek (1933), Kroc and Breneman (1936), and others with fowl; Evans and Simpson (1934), Riddle and co-workers (1928, 1931, 1933), and others, with pigeons; Schockaert (1931a, 1931b, 1932) with ducks; Witschi and co-workers (1935, 1936, 1937) with finches and sparrows. Several interesting conditions have been found in avian subjects by application of heterologous gonadotropic materials. Practically all phases of gonadal activity have been stimulated by mammalian preparations, although a number of in-

vestigators have reported an inability to influence ovulation, or frequency of egg-laying, in poultry with such reagents. However, it has been uniformly reported by many workers that human pregnancy urine preparations have little or no effect in birds, even in extremely high dosage. Similarly, preparations of the luteinizing fraction from mammalian hypophyses were found by Breneman (1936) to be not only of much lower gonad stimulating activity than follicle stimulating preparations, but even had the property of reducing FSH potency if mixed with it. With these facts established, it is of extreme interest to learn that LH, a mammalian gonad stimulator, has been found to act directly on an integumentary structure, the feather, in finches (Witschi, 1937). Another surprising finding in birds is the report of Bates, Riddle, and Lahr (1937) describing an action (inhibitory) on the gonad of pigeons by the lactogenic hormone, which typically affects integumentary derivatives. To our knowledge, the only comparable report is that of Guyenot, Moskowska, and Ponse (1932) who claim that pituitary implants have a direct stimulating action on certain nuptial integumentary structures in a toad, *Bombinator*, even after castration.

It is therefore quite apparent that the factor of species specificity of gonadotropic hormones cannot be very readily evaluated in birds, at least from the available data. Some especially directed research is needed to make possible such an evaluation. The avian gonad seems to respond practically as well to heterozoic pituitary as to its own (Witschi, 1937). Nevertheless, it is prevailingly true of almost all work with the birds that very large doses, in terms of rat units, were used to produce the gonad stimulation discussed by the different authors. This point manifestly requires further study.

As a matter of fact, Kroc and Breneman (1936) point out the marked difference of potency of rat pituitary implants in homoplastic application, and in young chicks, and suggest a gonadotropic species variation as the basis for this result.

Bird pituitary applied in other vertebrate classes has yielded some interesting results. Houssay and Giusti (1929) and Creaser and Harkaway (unpublished data) have shown the inability of chicken pituitary to induce ovulation in the toad and the frog, respectively. Stein (1934), on the other hand, found that fairly large doses of fowl pituitary did provoke ovulation in the salamander, *Triturus viridescens*. Zavadovsky (1929) claims to have found chicken pituitary quite active in gonad stimulation in mice. In the early work of Smith and Engle (1927) pigeon pituitary transplants were found without gonad stimulating action in immature mice. Using somewhat larger doses of pigeon glands Lipschütz, Kallas, and Wilckens (1929) were able to demonstrate a slight gonad response in the mouse. Benazzi (1937) adds that doses of 11 pigeon pituitaries are without apparent effect in young rats. When such results are compared with the striking gonad stimulation produced in the immature rat or mouse by one or two homoplastic pituitaries, or glands from other mammals, the difference in potency assumes possible significance to the species specificity problem. Further, Riddle and Schooley (1935) demonstrated the definite effectiveness of as few as 5 homoplastic implants in the young pigeon. In the experiments of Riddle and Schooley 9 rat pituitaries produced a degree of weight stimulation in the immature pigeon testis comparable to that produced by the homoplastic treatment, furnishing an additional example of the apparently indiscriminating responsiveness of the bird gonad to

extra-specific gonadotropic factors. It must be noted that in contrast to the results with pigeon pituitary, Witschi, Stanley, and Riley (1937) and Leonard (1937) found turkey and chicken pituitaries, respectively, to be quite potent in gonad stimulation in the rat.

REPTILES

The Reptilia have received scant attention from endocrinologists, but their importance from the phylogenetic standpoint invites further study. Mating behavior and histological evidence of gonad stimulation have been produced in the lizard, *Anolis*, by L. T. Evans (1933, 1935a, 1935b). Somewhat similar results were obtained by Herlant (1933) in the lizard, *Lacerta*, and the slow-worm, *Anguis*. Both of these workers used mammalian anterior pituitary and human pregnancy urine preparations. Cunningham and Smart (1934) report ovulation in *Lacerta* and *Anguis* after injection of a beef pituitary extract into fully ripe females. Large doses of sheep pituitary extract (9 to 18 cc. of Parke, Davis & Company extract in six weeks) produced slight gonad stimulation in young alligators in the experiments of T. R. Forbes (1934). In a recent paper presenting some work with the horned lizard, *Phrynosoma cornutum*, Mellish and Meyer (1937) provide some important data. They found that preparations of FSH, LH, and gonadotropic antagonist, each representing about 1.5 to 2.0 grams of fresh mammalian pituitary, and pregnant mare's serum extract, all lead to an increase in ovary weight due to increase in vascularity and yolk deposition in developing eggs. This striking demonstration of the ability of different gonadotropic fractions to elicit similar responses in a lower vertebrate lends confirmation to the same tendency observed in the amphibia. This phenomenon ad-

vances some interesting possibilities in connection with the evolution of the gonadotropic complex in higher vertebrates. Further study of the reptiles should prove a valuable source of information of this type.

In contrast to the obvious inefficiency of concentrated mammalian gonadotropic materials in reptiles are the experiments of Houssay (1930) who produced ovulation in the large snake *Xenodon merremi* with as few as five homoplastic pituitary implants. In the only reported case of application of reptilian hypophyses to another vertebrate type, Houssay and Giusti (1929) found that doses of 10 *Xenodon* whole pituitary implants gave no indication of gonad stimulation in the toad *Bufo arenarum*.

FISHES

Like the reptiles, the fishes should yield information of great interest to the comparative physiologist. At present the data of pituitary research is still too meager to permit generalization. Below the fishes in the chordate scale there is no organ comparable in structure and function to the pituitary body. The anatomical and physiological significance of pituitary structure and cytology in cyclostomes and elasmobranchs is still not clearly understood. In fact, the knowledge of the physiological significance of the pituitary of even the bony fishes can in no way be compared to that of the mammals, birds, and amphibians.

The interest in fishes as a basis for a pregnancy test has prompted a certain amount of study of the effect of mammalian gonadotropic hormones. The gonad stimulation of such preparations has in almost all reports been found lacking, or of negligible proportion by Fleischmann and Kann (1932) with prolán in the bitterling, Glaser and Haempel

(1933) with mammalian pituitary extracts in the bitterling, Koch and Scheuring (1936) with prolán and pituitary extract in the rainbow trout, and Owen (1936) with prolán in the bitterling. In the rainbow trout experiment doses of prolán as high as 3000 rat units, administered in six divided doses, had no recognizable stimulating effect. However, all of such data, whether positive or negative, cannot be accepted unequivocally because of the variability among fishes with regard to the length of time during the year in which the gonad is fully mature. Certain authors have failed to observe this factor, as might be inferred from their failure to mention it, or to use fish in a definitely sexually inactive state, together with suitable controls.

Schreiber (1936) has reported the only clear instance of gonad stimulation in a fish with a mammalian preparation. In his work with the eel, *Anguilla*, he was able to stimulate spermatogenesis with 250 rat unit doses of prolán.

As in the case of the amphibia, homoplastic pituitaries or glands from other fishes are definitely more successful agents for gonad stimulation in fishes. Houssay (1931) has produced ovulation in the fish, *Cnesterodon decemmaculatus*, by 1 to 3 pituitary implants from two other fish species, *Micropogon opercularis* and *Lucioperca melodus pati*. Von Ihering (1935) produced ovulation in sexually ripe female and male *Astyamox* and *Prochilodus* by treatment with less than 10 hypophyses from the fish *Hoplias malabaricus*. In an experiment with fish with very immature gonads, and therefore not comparable to those of the work of Houssay and von Ihering, Cardoso (1934) was able to stimulate growth in ovaries and testes of *Pimelodus clarias* with rather large doses of fish pituitaries. In these experiments 70 to 100 pituitaries administered over a

period of 10 to 18 days produced a great increase in gonad size over that of untreated controls (as much as five-fold). Since the pituitaries which were used weigh only .9 milligram, the dose was not as large as it might appear, but it would be of value to investigate the effect of mammalian hormones on an immature gonad to provide a comparison. Noble (1936) has been able to induce ovulation in the common aquarium fishes *Betta splendens* and *Lebistes reticulatus* with leopard frog pituitaries.

In some experiments, already briefly mentioned, large doses of whole pituitaries of various species of fishes were found unable to induce ovulation in mature frogs by Creaser and Gorbman (1935, 1936). Pituitaries from the perch, *Perca flavescens* (as many as 74), wall-eye pike, *Stizostedion vitreum* (16 glands), lake trout, *Cristovomer namaycush* (24 glands) were without gonad stimulating effect in *Rana pipiens*. In some recent experiments we have found *Rana pipiens* refractory to doses of 4 to 16 of the large pituitaries of the dog shark, *Squalus suckleyi*. These experiments are in agreement with the earlier work of Houssay (1929) who found that pituitaries of the shad were without effect in the toad *Bufo arenarum*. Wills, Riley, and Stubbs (1933b) have demonstrated a positive ovulation inducing capacity of *Lepisosteus* (gar pike) pituitaries in the toad *Bufo americanus*, and in one specimen of *Rana pipiens*. The latter datum deserves checking and should prove of considerable significance if verified, since *Lepisosteus* is phylogenetically more closely related to the amphibian forms than any of the fishes studied so far. Del Castillo and Novelli (1938), using rather small (ca. 13 milligrams) doses of fresh pituitary of four fish species: *Cynoscion striatus*, *Menidia platensis*, *Merluccius hubbsi*, and *Luciopimelodus pati*, were not able

to produce any significant weight change in the ovaries of 30 to 50 gram rats.

In summary for this group it may be said that there appears to be a definite loss in gonadotropic efficiency in reciprocal pituitary exchange between the two phylogenetically distant vertebrate groups, the mammals and fishes. This may be contrasted to the ready effectiveness of homoplastic treatment in each of these groups. Between the fishes and the more closely related amphibia, although there is a marked reduction in gonadotropic efficiency in reciprocal pituitary exchange, at least two experiments reliably indicate the ability of each to produce ovulation in the other taxonomic group. As already pointed out, these conclusions require the weight of further experimentation.

ANTIHORMONES

If the gonadotropic hormones are associated with species specific proteins it would be expected that chronic injection of these substances in a foreign species would lead to the formation of specific antibodies antagonizing their action. Most of the recent work with these "antihormones" indicates that they are species-specific for the animal source of the hormone. There are already too many reviews of the antihormone problem (Collip, 1938; Gordon, 1937; Thompson, 1937a, 1937b) which attempt to collect and reconcile the voluminous and often controversial literature, to make necessary more than an outline of the main features of this work as they apply to the gonadotropic hormone species specificity problem.

That the "antihormone" is a serum antibody, and therefore produced by an immune response to a foreign protein, seems to be indicated by the ability of subminimal hormone doses to lead to its

appearance (Twombly, 1936), by the inability of large doses of homologous gonadotropins to produce the resistant state (Katzman, Wade, and Doisy, 1937), and by the apparent involvement of the reticulo-endothelial system in its production (Gordon, 1937). The actual demonstration of the antibody nature of the antihormones by the usual serological technics has proven elusive. Gustus, Meyer, and Dingle (1935), Brandt and Goldhammer (1936), and others have shown precipitin or complement-fixation titers do not parallel the antigonadotropic potency of resistant sera. In fact, Brandt and Goldhammer regard the method devised by Collip and Anderson (1934) for determining antihormone activity merely as another suitable procedure for demonstrating the antibody content of a serum produced against an antigen with a typical physiological action. As Zondek and Sulman (1937) have observed, a number of authors who have reported that antihormones produced by them inhibited hormones other than the one used in their production, failed to note whether the strength of the inhibition was the same in each case, or they neglected to use a procedure which could show this. Immunologists have long been able to show that antibodies may be partially effective against proteins slightly different from those proteins against which they were originally elicited. This fact may be the basis of the "partial-specificity" of antihormones reported by some authors. Rowlands (1938) has recently been able to produce "pro-gonadotropic" sera by chronic injection of certain heterologous gonadotropic extracts. He suggests that this result may be due to the appearance of antibodies against the gonadotropic antagonist. If such a contention can be maintained, it seems not improbable that antihormones are pro-

duced against each gonadotropic fraction in a given extract used in chronic injections. Such a phenomenon might be the basis of the "organ-specificity" noted by Zondek and Sulman (1937). This same possibility might be easily a factor accounting for the variation in the reported results in testing a given antihormone-containing serum against different gonadotropic extracts, and it might therefore be the reason for some of the disagreement in experiments designed to investigate the species specificity of antihormones. To the difficulties of obtaining uniform results in demonstration of antihormone species specificity can be added the fact that different extraction procedures may cause different kinds and degrees of denaturation. The reality of this possibility is revealed in the work of Werner (1936a, 1936b) and Spielman and Meyer (1938).

In summary, it may be concluded that antibody nature of serum antigonadotropic substances has been demonstrated beyond reasonable doubt. This fact in itself proves the existence of a species variation in gonadotropic materials. The actual demonstration of the species specificity of antihormones has been attended by certain difficulties, but most investigations devoted to the study of this point have succeeded in showing such a species specificity.

CONCLUSIONS

Further than providing a substantial confirmation of the existence of gonadotropic hormone species variation, the study of antihormones does not contribute to the species specificity problem. In the evaluation of the physiological significance of this hormone variation the more direct method of hormone exchange between species must be used. This method has shown, in spite of the confusing ele-

ment of the plurality of the gonadotropic factors, that the effectiveness of a gonadotropic hormone in a foreign species tends to vary directly with the phylogenetic proximity of the donor and recipient species. In some instances the loss in effectiveness in such a hormone exchange may be so great as to lead to an apparent refractoriness by the recipient species to rather large doses of the hormone. The presence and the possible practical significance of this species factor should be considered by all investigators who are treating animals with extra-specific gonadotropic materials. It is conceivable that this factor may be operating in the well-known unsatisfactory state of clinical pituitary therapeutics. Furthermore, it becomes clear that if there is an appreciable variation of responsiveness of a given test animal to hormones from different species sources, then bioassay "units" do not represent equivalent absolute units

of hormone, but only the amount of hormone required to produce a given test reaction in the particular animal species under consideration. The amount of error introduced into bioassay by this factor remains to be ascertained.

SUMMARY

On the basis of experiments involving treatment of the leopard frog, *Rana pipiens*, with various extra-specific gonadotropic materials, and a review of the literature, it is concluded that a qualitative species variation exists in gonadotropic hormones. This variation may be great enough between widely separated donor and recipient species to lead to an apparent ineffectiveness of the hormone. The possible practical meaning of such a variation is discussed.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

ECOLOGY LOOKS HOMEWARD

Being a review of *Plant and Animal Communities*. (Notre Dame, Ind., The University Press, 1939. Pp. 1-255.)
By Thomas Park, Hull Zoological Laboratory,
The University of Chicago.

I

It is no longer front page news to report that ecology is seriously in need of a thorough housecleaning followed by a well-planned program of refurbishing. Such a conviction has been smoldering and growing among biologists for several decades past. Happily, certain ecologists of critical mind have shared this general opinion and are attempting to do something about it. The present review hopes to evaluate some of the measures that are being tried. The ills of ecology are not necessarily unique to that discipline but are, in part, the common inheritance of all rapidly growing sciences. In the stricter sense genetics and ecology were both conceived in the nineteenth century and born around nineteen hundred. Genetics was a lusty infant even at birth and soon attained the modish position it occupies today. Ecology grew falteringly and, as was also true of early genetics, exhibited a great amount of careless observation and experiment, misdirected over-enthusiasm and lack of intellectual focus. The unfortunate point is that ecology still makes just these same errors. There seems no doubt but that the field

should occupy a real place in theoretical biology, but is it moving in that direction; and, if so, is it moving there as surely and as swiftly as other biological disciplines? The answer to this question must be a somewhat evasive one. Part of the difficulty lies in the fact that ecology is an unfocussed field from both the historical as well as the modern viewpoint. The antecedents of ecology were varied. Around the turn of the century it drew principally upon natural history, general physiology, taxonomy, and physiography. It soon became apparent that the mere inclusion of certain facts from certain fields would neither develop nor constitute a self-delineated biological discipline. So, other fields were rapidly drawn in—more analytical aspects of biology, statistics, demography, climatology, and so on. The result, while expanding the frontier, bewildered even more the major issues. To make matters worse the ecologists working with animals and plants rapidly took out divorce papers on the grounds of incompatibility. This soon reached a state where, in an academic Nature, plants were completely independent of animals and animals were only crudely dependent upon plants.

What has this somewhat sombre pre-amble to do with the book under review? I think the answer is clear. Lately there are signs that ecology is trying to put its house in order. These signs are not numerous. Frequently they point to the

left rather than to the right. However, there is a chance that they presage an ecological millennium. Let us examine critically the book, *Plant and Animal Communities* in this light.

In the late summer of 1938 a group of plant and animal ecologists were invited to Cold Spring Harbor for a week to present papers dealing with selected phases of ecology. The *entrepreneurs* of the symposium were Doctor Stanley A. Cain (a contributor) and Doctor Theodor Just (editor of the proceedings). The motives underlying the symposium were somewhat similar to those just discussed. It was felt that ecologists working in diverse aspects of their subject should be brought together and through discussion, both leisurely and formal, stimulate each other and arrive at higher-order concepts. Actually this was an ideal not attained. The meetings enunciated neither new nor revolutionary ideas and directly did little to integrate a field badly in need of integration. What did happen, and herein lies the first value of the symposium, was that ecologists found themselves when assembled fairly self-critical and ready to attack time-honored but rather pristine traditions. In short, some good guns were fired. This is a valuable point to emphasize since it is not so detectable in reading the book, and, since indubitably it was the high point of the effort.

II

Let us turn our attention to a more conventional side of reviewing. The symposium and the book consisted of the following ten papers:

- (1) Plant Associations on Land. Henry S. Conard.
- (2) Littoral Marine Communities. G. E. MacGinitie.
- (3) Fresh-Water Communities. Frank E. Eggleton.
- (4) The Biome. J. Richard Carpenter.
- (5) The Individualistic Concept of the Plant Association. H. A. Gleason.
- (6) The Unistratal Concept of Plant Communities (The Unions). Theodor Lippmaa.
- (7) The Climax and its Complexities. Stanley A. Cain.
- (8) Social Coördination and the Superorganism. Alfred E. Emerson.
- (9) On the Analysis of Social Organization among Vertebrates, with Special Reference to Birds. N. Tinbergen.

- (10) Analytical Population Studies in Relation to General Ecology. Thomas Park.

It is patent from the list of titles and authors that the proceedings were diverse and far from comprehensive. As mentioned earlier this was part of the original plan. It would be redundant to review each paper in detail but certain points lend themselves for discussion.

Interestingly enough, the botanists and zoölogists, by and large, were concerned with different aspects of ecology. This is significant because it stresses the fact that bio-ecology is a neat term as well as a desideratum, but, to date is far from actual realization. Of the two groups, the botanists were more unified in that their polemics centered largely around ecological terminology. This meant that ideas and discussions were sprightly, entertaining, occasionally valueless and even apologetic—*qui s'excuse s'accuse*. There is a tendency in scientific work for a term *per se* to possess great personal emotional appeal. A value of the Cold Spring Harbor papers was that they tore down many terms, patently bad, and oftentimes, though not always, developed *concepts* to which a term could be assigned. These concepts revolved about methods of organizing the plant community. The plant ecologists asked this commendable question: granting that there are associations of plants extending over the earth, and, granting that these associations have a certain biological unity, how may the basic organization of such communities best be analyzed? I think this is a reasonable statement of the interests of many of the botanists present. In answering the question, however, diverse opinions became apparent. In certain cases it appeared that these opinions lacked a factual background; in other cases, they seemed to be adequately substantiated.

Conard, in a paper particularly noteworthy for its historical approach, stressed the new development of plant sociology. He defines the goals of this field (p. 22) as, "(1) An understanding of the Order of Nature," and (2) "Directions for the wisest use of the land." The field of plant sociology was also represented by Lippmaa who developed the "unistratal" concept of plant community analysis.

This concept holds that floral associations are subdivisible into basic units that represent strata or layers in the community. These units are supposed to have an ecological reality. It is suggested that they can be studied as centers of organization and analyzed in terms of their intra- and inter-competitive relations. "The elementary units of homogeneous and relatively stabilized vegetation (*i.e.*, in equilibrium with the habitat) are one-layered associations, characterized by a definite floristic composition and by their ecology." (p. 118)

A different approach to the same general issue was developed by Carpenter in his paper on the "biome." Instead of primarily stressing a small unit as did Lippmaa and building up from that point, the protagonists of the biome concept reverse the procedure, stress a floristic and faunistic unit of geographic extent and work down to smaller categories. Carpenter gives the following definition of the biome: (p. 75)

The primary unit of bioecology is the biome, a community of formational rank in the largest sense of the term. The biome is characterized by uniformity of physiognomy of the plant climaxes and in a lesser way by the climax stages. It is characterized by a combination of major and minor influent animals, a few climax influents, and many small influents and subinfluents. A certain grouping of species and varieties is characteristic of each biome. The biome or bioecological formation is based upon both plants and animals. Bioecology considers that plants and animals are inseparably united in the structure of any community.

There is a certain amount of verbiage in this definition. It describes a concept in terms that themselves may be difficult to define. However, Carpenter's paper cogently ties together a good deal of information about the biome and has the virtue of an excellent bibliography. The strength of the biome concept lies in that it recognizes a *bio-ecology*—a balanced evaluation of plant and animal interaction in nature. A weakness lies in that it has not actually done much to date towards developing this science.

In one of the strongest botanical papers Cain discusses the concept of climax communities. This paper is strong in that the author has taken pains (1) to view the climax with a well-rounded biological perspective; (2) to interpret carefully the

opinions of various leaders in plant ecology, especially Clements, and (3) to provide the reader with an extended bibliography. The paper also deals at some length with a complex and esoteric terminology. To a zoologically-minded reviewer this appears a debit. The reviewer, however, is vulnerable in making such a point since there is the very real danger that he may not fully comprehend the ideas expressed by the terms. Nevertheless, it is difficult to appreciate and sanction an intricate terminology when it seems to lack preciseness.

The final botanical paper by Gleason on the individualistic concept proved to be a stimulating theoretical essay. Gleason points out that there are three philosophical ways to view the plant association. In his words these are, (p. 93)

1. The association is an organism, or a quasi-organism, not composed of cells like an individual plant or animal, but rather made up of individual plants and animals held together by a close bond of interdependence; an organism, or quasi-organism with properties different from, but analogous to, the vital properties of an individual, including phenomena similar to birth, life, and death, as well as constant structural features comparable to the structures of the individual.
2. The association is not an organism, but is a series of separate similar units, variable in size but repeated in numerous examples. As such, it is comparable to a species, which is also composed of variable individuals. Under this view, the association is considered by some to be a concrete entity, merely divided into separate pieces, while by others the association as a whole is regarded as a mental concept, based on the common characters of all its separate pieces, and capable of typification by one or more of those pieces which most nearly approach the average or ideal condition.
3. The vegetation unit is a temporary and fluctuating phenomenon, dependent, in its origin, its structure, and its disappearance, on the selective action of the environment and on the nature of the surrounding vegetation. Under this view, the association has no similarity to an organism and is scarcely comparable to a species.

Gleason designates the last viewpoint as the individualistic concept which he implements in his paper. He concludes with the statement that, "The individualistic concept is totally at variance with the idea that the association is an organism, represented by many individuals, and also does not admit an analogy or homology between the species and the association." (p. 108)

An opposing theoretical position is taken by Emerson in a scholarly paper on social coördination. It is to the credit of the symposium leaders that both points of view were so ably represented. Following Spencer, Wheeler, Lloyd Morgan, Child and others, Emerson discusses at length the striking similarities, both ontogenetic and phylogenetic, existing between a complex social colony (e.g., a termite nest) and an organism. On the basis of these analogies the social colony is designated a "superorganism"—an unfortunate term—and the thesis developed that it is of fundamental significance to view higher levels of biological association in this light. An interesting point emerging from Emerson's remarks is that the superorganism frequently becomes so highly integrated that *it* is the unit upon which selection operates and not the individual. For certain cases this seems incontestable.

I have no desire to contrast in any detail the philosophical aptness of the views expressed by Emerson and Gleason. Both have some evidence in their favor, and while personally I strongly subscribe to the idea that a population has a certain statistical uniqueness not possessed by an individual organism, I think the reader should decide for himself at what point this uniqueness becomes "social." Suffice it to say that these two papers are stimulating contributions, devoid of questionable terminology and suggestive of future investigations.

III

The strictly zoölogical efforts of MacGinitie, Eggleton, Tinbergen and Park were all essential in that they covered material of unquestioned importance for modern ecology. They were not, however, closely integrated and suggest by inference that animal ecologists are thinking along more diverse lines than are plant ecologists.

MacGinitie, in a critical and praiseworthy report, discussed littoral marine communities. The major point developed by this author was that a thorough and complete understanding of the individual life-history of each component of the community is essential in a study of any bio-

coenosis. MacGinitie's remarks were well tempered by the critical attitude. He expressed considerable doubt as to the value of much of the terminological type of research popular among ecologists today. His sound plea was for more work and less nomenclature.

Eggleton dealt with fresh-water aspects of ecology. His paper was essentially an outline of elementary textbook information about the scope and emphases of limnology. Since no points of general theoretical interest emerged, and, since the paper offered nothing particularly new either in organization or content this contribution was below the standard set by many of the other authors.

In an interesting paper on social coördination in birds Tinbergen reviews a good bit of material collected largely at his laboratory in Leiden. His basic problem parallels much of the work of Allee and Noble in this country. Tinbergen attempts to analyze minutely behavior responses between one bird, the "actor" and another, the "reactor." For many cases it is shown that the reactor responds specifically to a specific stimulus or signal produced by the actor. In sum, through careful observation it is demonstrated that many major behavior responses between two individuals may be described and frequently it is possible to predict what will happen if the actor offers a certain stimulus to the reactor. This is an instructive paper primarily because it suggests what can be accomplished by skillful observation. The paper is an addition to the symposium in the sense that it formally delineates an active field of research that has some ecological implications. However, there is no attempt made to relate the contents of the paper to wider ecologic principles. This is regrettable.

The final paper by Park attempts to survey the major developments of population research and to suggest how these studies may and do contribute to ecology. A brief review of statistical and experimental population phenomena based largely on work with microorganisms, *Drosophila* and *Tribolium* is followed by an attempt to relate these findings to the natural population and latterly to the

community. The paper is not too successful in the last part. The author is able to show that the laboratory studies yield data intrinsically interesting but the argument loses some of its cogency when applied to the analysis of community problems. However, it still appears that a closer wedding between the analytical and field disciplines will eventually materialize. There is a brief discussion of this paper by Doctor G. F. Gause of Moscow.

IV

In concluding, it would seem appropriate to take a final account of some of the issues raised in this volume. Obviously, the mere existence of the symposium, to be followed by the book, recognizes that there is a felt need for the coordination and formalization of ecology. This in itself is an important contribution. Happily, the contribution is further enhanced by the tenor of the papers which dealt with those aspects of ecological research that appealed to their authors as promising and significant. Differently put, the book is a good index of what progressive ecologists are thinking about. Such an index is particularly useful when it emphasizes, either by design or inadvertence, the errors and mistakes of ecology and recommends corrective measures. In places the book is good at doing just that.

The above then are the prime attributes of the Conference's published record. In my opinion they outweigh the less desirable features. However, the latter are present and must be mentioned briefly. The book fails to leave with the reader any consistent pattern into which ecologic concepts can be approporiated. There is no real coherency of the material presented and there are certain essential omissions. Ultimately ecology must cease to be a

descriptive, qualitative science and become quantitative in character. Dealing with order and arrangement of biotic or group phenomena this seems completely inescapable. The present book is quite inadequate from this viewpoint. There are few places where a statistical approach is envisaged or even recognized. This is in no sense a specific criticism of the authors or the leaders of the conference. Rather it is a fault that must be laid at the doorstep of ecologists generally. The Cold Spring Harbor enterprise offered a splendid opportunity to encourage quantitative ecology. It is harder to criticize modern ecology on the ground that it is overemphasizing terminology. Such a criticism may be merely the personal bias of the reviewer. It does appear, however, that the Conference displayed a greater enthusiasm for terms than the present development of facts justify.

Other less major criticisms of the book may be enumerated. Most readers will probably feel that the printed discussions following each essay are so condensed and cryptic as to be practically valueless. This is one place where the book does the symposium an injustice. At the meetings the discussions were excellent. It is also unfortunate that the volume is poorly bound, lacks an index, and contains a number of typographical errors; since undoubtedly it will be contrasted to its disadvantage with the quantitative biology series. The latter are good examples of careful craftsmanship.

In conclusion it is worth restating the opinion earlier expressed that, despite obvious faults, *Plant and Animal Communities* is a thought-provoking, timely, stimulating and moderately critical book. It deserves a place in the library, and more importantly in the thinking, of all well-read biologists.

BRIEF NOTICES

EVOLUTION

LIFE'S BEGINNING ON THE EARTH.

By R. Beutner. Williams & Wilkins Co., Baltimore. \$3.00. 9 x 6; x + 222; 1938.

The belief in the spontaneous generation of living matter from inert matter has perhaps always been more widespread

than is commonly realized. From Vergil's account of bees down to the modern country-side superstition about horsechairs and snakes ordinary people have found little difficulty in accepting this theory.

The modern exponent of spontaneous generation bases his belief not on empirical but on rational grounds. On the premises

of cosmic philosophy he argues that when the earth came into existence its condition was such that water could occur only in the form of steam, making impossible the existence of any form of life now known to us. Therefore, when life finally appeared, it must have been spontaneously generated. This conclusion is not unassailable, for it takes no cognizance of the theory of panspermia advocated by Haeckel and Arrhenius, that living matter may have come to the earth from interstellar space. And the logic by which it is reached, while sound, is nevertheless only logic, and he who uses it is arguing not as a scientist but as a philosopher.

Yet there is quite a large body of evidence in support of the theory of spontaneous generation which is presumptive even if circumstantial. The book under review is a discussion of this evidence.

The reader on finishing it is likely to be surprised at the great amount of experimentation that has been performed within the past few years in the way of imitating the structure and activity of living matter, also at the great resemblances between artificial "plants" and their living prototypes, as brought out by the many excellent illustrations with which the book is provided. Incidentally, the caption under one of the illustrations designates the plant shown as a cactus, which it obviously is not. The reader is also likely to have the feeling that despite the wealth of material compressed between the covers of this book all that the author has really accomplished is the identification of the dynamics of living matter with that of inert substances. The statement on the cover about bridging the chasm between the two kinds of matter seems a bit premature. The fundamental question as to the origin and nature of life seems destined to remain unanswered for a long time to come.

There is no index to the book, but the orderly and systematic arrangement of its subject matter makes one unnecessary.



THE EVOLUTION OF GENETIC SYSTEMS.
By C. D. Darlington. *The University Press, Cambridge; The Macmillan Co., New York.* \$2.75. 8½ x 5½; x + 149; 1939.

It would have been well could this book have been expanded to between three and four times its present bulk. The author has been so economical with words (apparently a characteristic of modern scientific literary style) that his meaning is quite obfuscated. This is unfortunate, as the book is extremely scholarly and quite significant.

The bibliography contains 74 items, of which 55, or more than half, have appeared during the past five years, showing that the author's conclusions are based on absolutely the most recent research. Perhaps the most important part of the work deals with the evolution of sex. It is well known that the sex chromosomes of all animals are not homologous with each other, but it is not so well known that some of them may be homologous with somatic chromosomes of other animals. In other words, chromosomes undergo changes of function with evolution just as somatic structures do. It is obvious that this must be the case, for new chromosomes must be derived from old ones, but observed instances of it are not plentiful.

To anyone who wished to keep posted on the most recent developments in genetic theory this book will prove indispensable, but such a use of it is only incidental to the author's intention. To him the genetic theory is much more than a hypothesis—"it is the key with which the door between the physical and biological sciences is being opened." But the more catholic devotee of science for whom this book obviously is intended is likely to have trouble getting the key into the keyhole.

The index covers eleven pages.



THE APE IN ANTIQUITY. *The Johns Hopkins University Studies in Archaeology*, No. 27. By William C. McDermott. *The Johns Hopkins Press, Baltimore.* \$5.00. 9½ x 6; xi + 338 + 10 plates; 1938.

This is a very unusual book. It deals not with apes *per se*, but with what men through the centuries have thought about apes. The author has gathered his material from two kinds of sources—on the one hand, representations on artifacts and figurines, chiefly from the Mediterranean

can basin, but also from Egypt, Mesopotamia, Persia, India, China, and even the New World; and on the other hand, references in ancient literature, not only the classics but also many obscure documents.

In view of the controversy that raged during the latter half of the nineteenth century as to whether or not man was descended from the apes it is interesting to note that in the pre-Christian era the opposite view was widely held—that apes were degenerate men of a race called the *Cercopes* whose name is perpetuated today in that of *Cercopithecus*. The mythical home of these people was located on the island of Ischia, which in ancient times had three names, derived respectively from Greek, Arabic, and Egyptian roots, all of which meant "ape." It is interesting to speculate as to whether the name Ischia itself may not be connected with the ischial callosities which constitute such a conspicuous topographical feature of the baboon. The Barbary ape became established on the rock of Gibraltar in the second century. The first civilized person to see an anthropoid in its native habitat was Hanno, the Carthaginian, in the sixth century B.C. Yet more than a thousand years before Hanno a knowledge of apes had become widely disseminated among the Europeans, as a result of their commercial intercourse with the Egyptians.

The footnotes are numerous, averaging more than five to the page throughout the book. Nearly all of these are bibliographic references, which would have improved the book could they have been set out in the text, as many of them come from works not readily available. The bibliography itself is painfully brief—perhaps with such an extensive documentation a bibliography is not necessary. There are twelve pages of index, and the plates are photographic.



STRATIGRAPHY AND PALEONTOLOGY OF THE LOWER MISSISSIPPIAN OF MISSOURI. Part I. *The University of Missouri Studies, Volume XIII, Number 3, 1938.*

By E. B. Branson. *University of Missouri, Columbia.* \$1.25. 10½ x 6½; vii + 205 + 20 plates; 1938 (paper).

The stratigraphy and paleontology of the Chouteau and Glen Park limestones, and the Bushberg sandstone of Missouri are described in this first part of the study of the fossil fauna of the Lower Mississippian. The Chouteau fauna is dominated by brachypods, with the following forms occurring in the order given—bryozoans, crinoids, pelecypods, worms, corals, gastropods, cephalopods, blastoids, trilobites, fishes including conodonts, ostracods, sponges, and foraminifera. (This estimate is based on probability of being able to collect specimens and not on number of genera or species.) The genera that are lacking in the Glen Park region are significant; no *Avonia*, *Productus*, or *Pustula* is present, although all are abundant in the Chouteau, Bushberg, and Lower Mississippian formations in all parts of the United States. Spirifers are rare: the crinoid generic identifications are not even provisional, but impossible on the basis of the fragmentary material. The fish fauna of the Bushberg other than conodonts includes 12 species belonging to seven genera. The invertebrate fauna has been found in only one place.

Twenty plates, exhibiting from 13 to 43 well-executed figures are included in this study; also maps and illustrations of rocky formations. Part II, the next number of the *Studies* will complete the survey.



PREHISTORIC LIFE.

By Percy E. Raymond. *Harvard University Press, Cambridge.* \$5.00. 9¾ x 6¾; ix + 324; 1939.

All too often a student's introduction to paleontology is a fleeting one, included in a beginning survey of geology. Such an introductory survey may be as marvelous as the circus and just as stimulating to the beginner, but paleontology is not a side-show. It is a menagerie which includes as many rings and stages as any other circus.

For the past seventeen years Professor Raymond has been offering at Harvard a course under the title of Paleontology I. This book is the essence of his constantly changing series of lectures, presented to twenty-five classes of students. Professor Raymond's teaching is at once ortho-

dox and heterodox: orthodox in that it tells a conventional story, but heterodox in part, as the author explains, whenever it reflects only his personal views. Insofar as possible Professor Raymond has related the changing forms of prehistoric life to their changing environments. He succeeds in giving his subject a dynamic turn.



PRINCIPLES OF PALEBOTANY.

By William C. Darrab. *Chronica Botanica Co., Leiden; G. E. Stechert and Co., New York.* Guilders 7 or \$4.00. 9½ x 6½; [6] + 239; 1939.

Beginning with short chapters on the history and aims of paleobotany and the techniques employed in its study, the author progresses from the earliest of plants, the Psilopsida, to the present day floras. The more advanced Devonian floras, consisting of the Lycopsidea, Sphenopsida, and Pteropsida, are all carefully reviewed. The remaining fossil plants from the late Paleozoic, the Mesozoic and Cenozoic eras are discussed in chronological order. Other problems such as the the origin of the angiosperms, floral changes in spatial distribution, and the origin of existing floras form the remainder of the discussions presented in this book. The writer concludes with a chapter on the relationship of these plants. Altogether this constitutes a fine presentation of the present knowledge of paleobotany.



DIE STAMMESGESCHICHTE DER WIRBELLOSEN TIERE IM LICHT DER PALÄONTOLOGIE.

By Oskar Kuhn. Verlag von Gustav Fischer, Jena. RM. 6. 9½ x 6½; vi + 130; 1939 (paper).

This is a comprehensive report of factual data on invertebrate phylogenies based on paleontological findings. The author divides the invertebrates into seven groups. There are many excellent illustrations and charts on phylogenetic histories. No bibliography is appended since all sources are mentioned as they appear in the text. *Zur Stammesgeschichte der Insecta-Pterygota* by H. Haupt follows the monograph by O. Kuhn.

Kuhn's previous paleontological study of the phylogenetic histories of the vertebrates was reviewed in Vol. 14, No. 2 of Q.R.B.



GENETICS

THE AMERICAN SPECIES OF *CREPIS*. *Their Interrelationships and Distribution as Affected by Polyploidy and Apomixis.* Carnegie Institution of Washington Publication No. 504.

By E. B. Babcock and G. L. Stebbins, Jr. Carnegie Institution of Washington, D. C. \$3.00 (cloth); \$2.00 (paper). 10 x 7; 199 + 2 folding charts; 1938.

The taxonomic complexities of the genus *Crepis* (hawkbeard) are the result of the processes of polyploidy, hybridization, and apomixis which these plants have undergone in their evolutionary formation. In distinguishing the species the writers have taken three criteria into consideration: morphological likeness or distinctiveness, the degree of genetical isolation, and the degree of similarity in the evolutionary history of the components of the species.

The American group of *Crepis* probably originated by allopolyploidy from hybrids between 4- and 7-paired species of the Old World. After the original 11-paired species were formed in this country, they began to produce the higher, apomictic polyploids, and the formation of these has continued to the present time, greatly displacing the diploid forms. All the species of *Crepis*, including subspecies and apomictic forms, are described. There are keys, distribution maps, and drawings of involucre and achenes to help in their identification. This work constitutes a neat and valuable study of a difficult group demonstrating how genetics and cytology can clear up abstruse problems of relationship, evolution, geographic spread, etc.



VERERBUNG "ERWORBENER EIGENSCHAFTEN" UND AUSLESE.

By Walter Zimmermann. Gustav Fischer, Jena. RM. 17. (paper); RM. 18.50 (cloth). 10½ x 6½; xii + 345; 1938. The author, a botanist, deals with the

old and much discussed problem of the heredity of acquired characters (in 12 chapters) and presents at the end a large amount of literature drawn from many fields of science and philosophy. In the last section he reaches, in addition, some practical conclusions, especially regarding the origin and phylogenetic development of man. In the author's opinion, "heredity of acquired characters" is only possible insofar as organisms are able to acquire new qualities by changes of genetic factors and thus to transfer them to their offspring. But there is no "heredity of acquired characters" in the sense that personal changes of body and intellect cause a corresponding change in the genes. What conditions induce the hereditary change are in most cases unknown. As far as we know the stimulation from outside must directly affect the genes. The accumulation of favorable adaptations in phylogeny has come about by the continued selection of the fittest, in the sense of the classical theory of selection of Darwin.



ERBLEIDEN DES AUGES. *Handbuch der Erbkrankheiten. Band 5.*

By Max Bücklers, Wilhelm Clausen, Bruno Fleischer, Heinrich Harms, Adolf Jess, Walther Löhlein, Oswald Marchesani, Wolfgang Stock, Wilhelm Wegner. Georg Thieme Verlag, Leipzig. RM. 26 (cloth); RM. 24 (paper). 10 x 6½; xi + 310; 1938.

All the different eye diseases are systematically dealt with from the point of view of heredity by a number of eye specialists. Thus Bruno Fleischer deals with inborn deformities; Walther Löhlein with glaucoma in childhood, and glaucoma of adults; Wolfgang Stock with microcornea and macrocornea. Max Bücklers treats in detail the opacities of the cornea, hereditary changes of the position and form of the lens, and hereditary opacities of the lens; Oswald Marchesani deals with albinism, total and partial color-blindness; Adolf Jess with pigment degeneration of the retina, inborn night-blindness, and some other hereditary diseases of the retina (glioma, neuro-epithelioma retinae, etc.). The refraction anomalies are pre-

sented by Wilhelm Clausen, squinting and hereditary motor disturbances of the eye by Heinrich Harms. Consideration is always given to the literature at the close of the single chapters.



PRINCIPLES OF GENETICS. *Third Edition.*

By Edmund W. Sinnott and L. C. Dunn. McGraw-Hill Book Co., New York and London. \$3.50. 9 x 6; xiv + 408; 1939.

Six years have elapsed between the second and third editions of this book (cf. Q.R.B., Vol. 8, p. 103). Considerable revision has been done, particularly in the latter half of the volume, in order to include new material and many new illustrations in the text without increasing the size of the volume. The basic method of treating the subject has not been radically changed. A new chapter on cytoplasmic inheritance has been added and elementary biometric methods have been briefly and simply treated in the section dealing with multiple factor inheritance.



GENERAL BIOLOGY

I KNOW AN ISLAND.

By R. M. Lockley. George G. Harrap and Co., London, Toronto, Sydney and Bombay. 10s. 6d. net. 8½ x 5½; 300 + 33 plates; 1938.

This is a book of birds and islands and is written by a man who lives with his wife and daughter on the otherwise uninhabited island of Skokholm off the coast of Pembrokeshire. Skokholm "had lain derelict for at least twenty years" before the author leased it and transformed the deserted Welsh island into a snug, comfortable home. In the first and last chapters of the book the author tells of his desire to live on an island sanctuary, of his search and discovery of the ideal place, of the history of Skokholm from the ninth century to its present occupation, and of the years which he has spent there with his family. The remaining chapters deal with the author's visits to other islands, such as Grassholm, Ramsey, Bardsey, the Blaskets, Heligoland, Fair Isle, North

Ronaldshay, the Faeroes, and the Westmanns. There is scarcely a page in the book which does not mention the profuse bird-life which he found everywhere and there are fascinating descriptions of puffins, razorbills, storm-petrels, guillemots, gulls, shearwaters, gannets, the rare Leach's fork-tailed petrel (found by the author on Sudurey in the Westmanns), and others too numerous to mention.

Although the author's paramount interest is bird-life, his colorful accounts of islanders show a keen understanding of human beings also. He points out how little contact many of these people have with the rest of the world and how little interested they are in outside affairs. There is the story of an old Blasket Island man who, speaking of a former islander, said, "He was the only man in Blasket who went to England's war with Germany and in my opinion he was always a half-mad man."

This is a simply and beautifully written book, well illustrated by photographs and maps.



ESSAYS IN PHILOSOPHICAL BIOLOGY.

By William Morton Wheeler. Selected by G. H. Parker. Harvard University Press, Cambridge. \$3.00. 8 x 5½; vi + 261; 1939.

In a foreword, Professor Barbour explains that the twelve essays by the late William Morton Wheeler presented in this volume have been reprinted for two reasons. First of all, most of them are out of print, and secondly, "these essays are unique in the history of American Biology." All will agree that the latter is the much more important reason and Professor Parker deserves the thanks of all biologists and scientists for the task he has so well undertaken. The selected papers are arranged in chronological order from that entitled: *The Ant-colony as an organism*, printed in 1911, to that published in 1934 under the title: *Animal societies*. Included are also our favorites: *The termitodoxa, or biology and society*; *The dry-rot of our academic biology*; *Emergent evolution and the development of societies*. Words of praise or comments on the essays would be entirely superfluous. They are veritable gems of scientific

literature, familiar to students of biological sciences who will welcome the opportunity to have them gathered here. Included is also a biographical sketch of Wheeler written by L. J. Henderson, Thomas Barbour, F. M. Carpenter and H. Zinsser.



WILD COUNTRY. *A Highland Naturalist's Notes and Pictures.*

By F. Fraser Darling. The University Press, Cambridge; The Macmillan Co., New York. \$2.75. 9 x 6½; vii + 104; 1938.

This is essentially a picture book, but a superb one. Fraser Darling is rapidly emerging as the world's leading field naturalist. He has the same zest really to live with raw nature and see what goes on that characterized his great predecessors in this now largely outmoded part of biology. The physical and social hardships that such a career necessarily involves are taken in stride. But beyond all this, and vastly more important, Fraser Darling brings to his work what none of the older field naturalists did in anything like the same degree—the rigorous critical attitude of the laboratory in the study of the behavior of unrestrained animals in their undisturbed natural surroundings.

The present volume demonstrates that, along with his observational and scientific penetration, Darling as a nature photographer has had few equals and no superiors. Every biological laboratory, private as well as institutional, must have this book on its shelves.



SAGA OF THE "DISCOVERY".

By L. C. Bernacchi. Blackie and Son, London and Glasgow. 10s. 6d. net. 8½ x 5½; xv + 240 + 48 plates + 2 maps; 1938.

The famed walrus in *Alice in Wonderland* was no more versatile in his talk than is Mr. Bernacchi. In telling of his own and subsequent adventures in the Antarctic wonderland, the latter gentleman does fail to mention cabbages, but this is compensated for by interesting comments on the lack of other greenery and fresh foods.

Since knowledge of vitamins was nil during the period when the Discovery was icebound, scurvy was as great an impediment to exploration as were storms and crevasses.

Although the tale of joys and hardships of this land of pioneers is an entertaining one, the biologist finds the latter half of the book of greater interest. This describes biological research expeditions into frigid seas, with particular reference to the problem of conservation in whale fishery. The behavior of seals, penguins, petrels, and skua gulls enters for its share of narration, with sidelights on the smaller animals and plants on which they feed. Throughout the volume maps and excellent photographs clarify the description.



NEW ENGLAND NATURALIST. *The Magazine of the New England Museum of Natural History*, Number 1.

Boston Society of Natural History. *New England Museum of Natural History*, Boston. 25 cents. 10½ x 7½; 20; 1938 (paper).

This journal is the new organ of the New England Museum of Natural History, and is intended to replace the earlier *Bulletin*. The first number is 21 pages in length, and contains 9 short articles of general interest in the field of Natural History; an announcement for special courses in nature study for Scout leaders given by the Education Department of the Boston Society of Natural History; an obituary of John Charles Phillips (1876-1938) who was a trustee of the Society (1915-1936); a list of new members and a list of new publications of the Society. The journal is well printed and generously supplied with illustrations. It should be an interesting and valuable addition to the library of any society or institution which has an active interest in the natural history of the fauna and flora of our New England states.



BIBLIOGRAPHY ON SOIL EROSION AND SOIL AND WATER CONSERVATION. U. S. Department of Agriculture. *Miscellaneous Publication No. 312*.

Compiled by Stanley H. Gaines, with Abstracts by Francesca Vincent, Marion Bloom, and James F. Carter. Government Printing Office, Washington. 60 cents. 9½ x 6; 651; 1938 (paper).

This bibliography, arranged under 31 general headings, is by no means confined to references to the United States, although these make up by far the larger part of the citations. Many other regions are included so that practically all types of geographic areas are represented.

The purpose of the bibliography is primarily to provide authors, subject-matter specialists, and students with a medium by which they may determine, with a minimum of time and effort, what others have written on a given related subject, whether it be scientific or historic in nature or merely indicative of the trend of public opinion. Consistent therewith, references to both popular and scientific material are included.

The abstracts, which accompany the references "are intended to amplify ambiguous titles, and in many cases, it is hoped, to serve the final purpose of the user of the bibliography." The authors' index, which covers 52 closely printed pages, gives some indication of the ground covered.



AN INTRODUCTION TO LABORATORY TECHNIQUE.

By A. K. Ansley. With a Foreword by F. H. Newman. Macmillan and Co., London and New York. \$4.50. 8½ x 5½; xiii + 313; 1938.

A useful book to have in the reference section of all science libraries. It deals with "various techniques employed in the many processes and methods used in laboratory maintenance." A few of the chapter headings will serve to give the reader the scope of the book: The care of laboratory equipment; Cements, lutes and solvents; Electric motors; Glass-blowing and glass-working; Insulators and their working; Optical projections of lantern slides; Storage cells; etc. In the appendix there is a section on first aid treatment for laboratory workers, and also a number of tables in which are given data on such subjects as densities of common substances, physical constants of the elements, conversion tables, etc. The volume is somewhat briefly indexed.

PLINY. NATURAL HISTORY. *With an English Translation. Volume I. Praefatio, Libri I, II. Loeb Classical Library.*

By H. Rackham. Harvard University Press, Cambridge; Wilhelm Heinemann, London. \$3.50 (leather); \$2.50 (cloth). 6½ x 4; xiv + 378; 1938.

In the introduction the author presents a brief biographical sketch of Gaius Plinius Secundus (Pliny the Elder) and a summary of the contents of Pliny's Preface and Books I and II of Volume I. The Latin text appearing in this book is printed from that of Detlefsen, Berlin, 1866, and checked by the Teubner edition of Ludwig von Jan re-edited by Karl Mayhoff in two volumes, 1905, 1909.

A splendid addition to the long list of scholarly publications of the Loeb Classical Library.



FUNDAMENTALS OF BIOLOGY, *Animal and Plant.*

By William C. Beaver. C. V. Mosby Co., St. Louis. \$4.50. 8½ x 5½; 896; 1939. The early chapters of this voluminous and comprehensive work are devoted to fundamental biological properties. Both plant and animal biology receive treatment, representative forms of twenty-eight animals and fifteen plants being compared anatomically and functionally in their respective systems. Genetics and evolution are briefly represented, as are the biochemical and biophysical phenomena involved in physiological processes.

An excellent feature of this book, not duly stressed by the average text, is the demonstration of the practical value of the study of biology. This is brought out by showing the applications to agriculture, fuel, conservation, medicine, and other aspects of human welfare. Although the drawings are artistically poor, there is an extensive glossary and a good index.



ETUDE MORPHOLOGIQUE ET BIOLOGIQUE SUR LES FLAGELLÉS INTESTINAUX PARASITES DES MURIDÉS. *Etude comparative des Flagellés du Cobaye.*

By Léon Morénas. Masson et Cie, Paris. 60 francs. 9½ x 6½; 234; 1938 (paper).

After describing his techniques and giving a list of the organisms found, the author presents his results, together with data obtained from the literature, on the morphology and biology of the intestinal Flagellata of rats and guinea pigs. The biological part includes studies on ecology and conditions determining parasitism, such as the pH of the intestinal tract, diet regime, and floral bacteria of the hosts. The bibliography of 14 pages is listed under the headings morphology and biology. There is no index.



BIOLOGICAL SURVEY OF THE MOUNT DESERT REGION. PART VI. *The Insect Fauna with references to methods of capture, food plants, the flora and other biological features.*

By William Procter. Wistar Institute of Anatomy and Biology, Philadelphia. Free. 10 x 6½; 496; 1938.

Mount Desert Island occupies an interesting location between the Boreal and Transition zones. The biota consequently includes species typically found in northern or southern latitudes. The insects and spiders from the island are herein listed. While the list is admittedly not complete, it still remains a formidable one considering the area of the island that was surveyed. The index to the forms listed covers something over 30 pages.



SYMBIOSE DER TIERE MIT PFLANZLICHEN MIKROORGANISMEN. *Sammlung Götschen, Band 1128.*

By Paul Buchner. Walter de Gruyter and Co., Berlin. RM. 1.62. 6½ x 4½; 123; 1939.

This little book, an addition to the well-known Götschen series, is an authoritative introduction, for the layman as well as student, to the symbiotic life of land and water animals with plant microorganisms. It is supplied with illustrations, a bibliography, a glossary of terms, and a subject index.



UNIVERSITY OF COLORADO STUDIES. *General Series No. 423. University of Colorado*

Bulletin, Volume 26, Number 1. Containing: *Studies of Island Life*, by Theodore D. A. Cockerell; *Abstracts of Theses and Reports for Higher Degrees.*

University of Colorado, Boulder. \$1.00.
10 x 6½; 188; 1938 (paper).



HUMAN BIOLOGY

THE AMERICAN CRIMINAL. An Anthropological Study. Volume I. The Native White Criminal of Native Parentage.

By Earnest A. Hooton. With the collaboration of the Statistical Laboratory of the Division of Anthropology, Harvard University. Harvard University Press, Cambridge. \$10.00. 10½ x 7½; xvi + 309 + [493]; 1939.

CRIME AND THE MAN.

By Earnest A. Hooton. Harvard University Press, Cambridge. \$3.75. 9½ x 6; xvi + 403; 1939.

The bitter attacks against the Lombrosian ideas of a criminal man have been mainly from two sources. The first being represented by those penologists with a Messianic complex and the second by anthropologists and criminologists who have pointed out the obvious defects in the factual foundations of Lombroso's assertions. Through the efforts of the latter group, the theory of atavism has been rejected and strong doubts have arisen regarding the existence of criminal stigmata. The final blow was apparently struck by Goring who denied that criminals were differentiated at all physically from non-criminals. But, Goring's work although utilizing refined statistical methods has a number of flaws, not the least important being his preconceived notions on the subject. Hooton, among others, noted these defects and determined to reexamine the whole question. For over a decade, he and his associates have conducted an extensive anthropometric survey of the prison population in various sections of the country. In total, almost 11,000 male prison inmates in 10 selected states were measured as well as a small control group of about 300 civilians obtained in two of the states (Massachusetts and Tennessee). Some twenty odd measurements concerning body, head and ear

dimensions were taken on each subject and in addition observations regarding hair, skin, shape of head, ears and face were made. The results of the elaborate analysis of these data are presented in a technical series of volumes, the first of which is noted here, and in the semi-popular book which is also discussed in this review.

The first volume of the technical series is concerned with more than 4,000 white criminals, native born of native parentage. After making the necessary corrections for differences between states and between observers the main conclusion reached is that criminals as a group demonstrate physical as well as educational inferiority when compared to the civilian population. This is particularly true and found to a greater degree for recidivists. Moreover, Hooton finds that when criminals are classified according to body type there seems to be some association between physique and type of crime committed, as, for example, stocky build with sex and assault crimes, slender and short persons with larceny. The data also indicate that the criminals, as a group, have decreased pilosity, extreme variation in types of ear protrusion, preponderance of low and sloping foreheads.

These results are summarized in the book entitled *Crime and the Man* which includes also an outline of the results derived from the study of foreign born criminals, native born of foreign parentage and of Negroes. All the evidence points to the same direction, that on the whole the criminal is organically and physically differentiated from the general population. The author, therefore, suggests a reorientation of penology and criminology that will give due weight to the biological factor in crime.

Crime and the Man is written in an amusing vein with many ironic sarcastic shafts directed at certain groups of penologists. The layman will find it interesting and enjoyable not only because of its style but also for the unusual illustrating cartoons it contains. The first volume of the technical series is, of course, well written but the statistical information is not summarized in the clearest possible fashion. Neither volume contains any indication

of the great amount of literature, some good, some bad, that has accumulated in the years since Lombroso and Goring.



THE PASSING OF THE ABORIGINES. *A Lifetime spent among the Natives of Australia.*

By Daisy Bates. Foreword by Sir George Murray and an Introduction by Arthur Mee.

John Murray, London. 10s. 6d. net.

8½ x 5½; xviii + 258 + 12 plates; 1938.

Two civilizations cannot simultaneously occupy the same habitat. When the first European stepped upon Australian soil the doom of the aborigines was sealed. Just as the rabbit is supplanting the kangaroo and the sparrow the kookaburra so will it be only a question of time until the bush man vanishes into Kur'an'nup beyond the western sea, and the only choice that confronts the white man is as to whether his palcolithic brother shall be exterminated with kindness or cruelty. The one method is as efficacious as the other.

Rumors of the latter as long ago as 1899 impelled an Anglo-American periodical to send Mrs. Bates to Australia to make an investigation. Her observations led her to believe that whatever cruelty with which the Aborigines might have been afflicted was generally unconscious and always unofficial.

But Mrs. Bates' task was only beginning when she had completed her investigation of these rumors. For the next thirty-five years she remained living with these primitive people, ministering to their needs, helping them settle difficulties, and mediating in disputes between different factions, for unfortunately there is a great deal of intertribal jealousy in the bush. There are two distinct genealogical stocks represented, the dominant one having entered Australia only a few short centuries before the advent of the Europeans. Between these two there existed a condition of perpetual strife, and within each was a highly developed caste system with innumerable taboos that precluded any sort of amity.

The author, now 78 years of age, has recently returned to civilization to analyze and interpret the great quantity of an-

thropological data which she has accumulated. This will be for the basis of another report. The present work, while it contains much of an anthropological nature is primarily an account of her personal contacts with these people. Her associates in the bush were not attractive, judged by western standards. They were frankly cannibalistic, the women often eating the children which they bore to the dissolute whites to whom their black husbands had leased them, and not infrequently their pure blooded children as well, because they had a better flavor; the men who could not support all their wives devoured the superfluous ones, all sorts of cruelty were commonly practised and they never bathed, yet withal there were some outstanding individuals among them who showed strength of character in their own way.



WHITE SETTLERS IN THE TROPICS. *American Geographical Society. Special Publication No. 23.*

By A. Grenfell Price, with additional notes by Robert G. Stone. *American Geographical Society, New York.* \$4.00. 10 x 6½; xiii + 311 + 20 plates; 1939.

The problem of the fitness of the tropics for white settlement has drawn the attention of many students, especially in recent years, when a number of very timely contributions have appeared. It is just a year and a half, for instance, since a group of American workers under the leadership of Isaiah Bowman prepared a unique report, world-wide in scope, on the present limits of land settlement. This report was sponsored and published by the Council on Foreign Relations. And now comes another comprehensive synthesis, this time one which is devoted solely to the tropics and to white settlement. The author was interested particularly in the more scientific attempts to invade the tropics. Specifically, he wanted answers to the questions, why have white settlements failed in the past, and can they be expected to succeed in the future?

Working primarily in Australia, but also in Africa, in South America, in Panama, in the Caribbean, and in Florida,

Price set out to appraise as precisely as possible the measurable factors governing white acclimatization in selected areas and regions. The information collected from many types of white settlement has been recorded in this book. With the aid of modern technology certain white settlements seem to have achieved remarkable success. Yet Price does not offer much hope that the political outcasts from Central Europe will be able to find satisfactory homes in the tropics. His conclusion is the one to which all competent students of the problem seem to come, no matter how they approach the question. Except in certain marginal zones debilitating heat, disease, isolation, and competition with colored races of a lower standard of living stand as barriers to permanent white settlement.

This book comes forth under the auspices of the American Geographical Society, for whom it was edited by J. K. Wright, the author being in Australia. At the request of the Society, Mr. Robert G. Stone of the Blue Hill Meteorological Observatory, Harvard University, has contributed some additional data in the form of notes, especially bibliographical references, and some appendices on the results of modern physiological research in relation to human acclimatization in the tropics. The imprint of the American Geographical Society is a sufficient recommendation of the book. The Society's "special publications" are invariably outstanding.



AFRICAN WOMEN. *A Study of the Ibo of Nigeria.*

By *Sylvia Leish-Ross*. Foreword by Lord Lugard. Faber and Faber, London. 15s. net. 8½ x 5½; 367 + 8 plates + 2 maps; 1939.

Practically all the knowledge about the behavior of primitive women has been acquired by male observers, but the investigation reported here has been conducted by a woman and one, moreover, who has lived a good part of her life in Nigeria. The Ibo, whom she studies, are said to number over 3 millions and are mainly agricultural. While their contact with European civilization has been limited to missionaries and British officials

only, they apparently are already lacking in the rigid set of conventions and traditions so common to primitive peoples. All told, they seem to be a practical and intelligent people and this is manifest especially in the social relations between the sexes. The women participate actively in the agricultural work and in the trading derived from it. They work the fields toward which they assume exclusive proprietary feelings. They conduct trading and are predominant in the market places. As a result they are regarded as true helpmates by the husbands who take great pride in the accomplishments of their wives and allow them overt expression in community affairs. The most striking feature of this custom is that a sense of solidarity has developed among the women to a greater degree than among the men. So much so that a few years ago the women were able to stage an actual riot in protest against the taxation demanded by the British authorities. The description of the customs of the Ibo women is the central theme of the book but the author has added acute observations on the reactions of this group to the missionaries and to the customs of the European. These accounts are very amusing even though they reflect on the intelligence and the reform complex of the white man. Scattered throughout this work are many observations dealing with items of general interest to the human biologist. Aside from its scientific value the book will be found enjoyable for the style in which it is written. One point that might be criticised is the emphasis on the degree of equality given to the Ibo women in comparison to that noted among European and among other primitive peoples. As a matter of fact, it is realized that ethnologists have been guilty of some misinterpretations in this respect. Moreover, the author will find many of the customs she describes on this point common to white populations engaged in agriculture as, for example, among the Southern European groups.



ATLANTIC CIRCLE.

By Lord Moyne. Photographs by Lady Broughton. Blackie and Son, London and

Glasgow. 18s. net. 8½ x 5½; xii + 201 + 80 plates; 1938.

This is an interesting story well told. The author is the owner of a 200 foot yacht, and interested in all departments of natural science. For the better part of three years he and a group of congenial companions have circumnavigated the North Atlantic Ocean, in which they played a part similar to that of the Hancock Ensemble in the Pacific. The present work covers the personal phase of their experiences—the complete report of their archaeological, anthropological, and biological accomplishments cannot be made available without about a year of further study.

The author, being an Englishman, naturally writes from an English viewpoint and has English readers in mind. He expresses surprise at the magnificence of the Maya ruins in Middle America and regrets that they are not as well known as those of Egypt. This was the condition once, but the progress made by American archaeology in the past two generations makes it no longer so today. Perhaps the most interesting part of the book is that which deals with Greenland. Denmark has exhibited unusual intelligence in its policy toward Greenland. Although much pressure has been brought upon the Danes to open Greenland up for settlement and exploitation, so far the Danish government has remained firm and admits visitors only under great restrictions, and settlers not at all. The result is that Eskimos and Greenlanders are slowly increasing in population. We are told that the Eskimos are not brachycephalic as their physiognomies would seem to indicate, but have true dolichocephalic skulls. Their brachycephalic appearance is due to the heavy musculature of the jaw, which they develop by chewing the walrus hide and sealskin from which they make shoes and clothing in order to soften it.

A chapter on marine biology written in popular style concludes the book, and there are seven pages of index. The illustrations are from photographs, and their excellence makes the reader regret that they are not more numerous.

THE SEX CRIMINAL.

By Bertram Pollens. Foreword by Richard A. McGee. *The Macaulay Co., New York.* \$2.00. 8 x 5½; viii + 211; 1938.

The author regards society's present understanding of the sex criminal as at about the same stage as was its attitude toward the insane many years ago. "The sex criminal is not possessed of the devil and sending him to the electric chair or imprisoning him will not cure him nor will it deter others from becoming sexual psychopaths." The present incompetency of the law in the treatment of sexual offenses is deplored.

In the first place, we must discard the traditional legalistic attitude which takes into account only the actual act performed by the 'criminal,' and which classifies these acts into misdemeanors and felonies with commensurate punishments for each. Thus, according to our present law, one who 'indecently fondles' a little girl is guilty of 'impairing the morals of a minor,' and is guilty only of a misdemeanor punishable by a short prison term. Whereas one who has sexual intercourse with a girl seventeen years of age, with her consent, who may even be a prostitute, is guilty of rape, a felony, and may be sentenced to a long term in state prison. Actually, the first is far more dangerous than the second. In both cases, moreover, the actual acts performed are not as important as the motives underlying these acts and the psychological state of the individual performing these acts.

In this excellent study the author, senior psychologist in the sex clinic in the Rikers Island Penitentiary of New York City, and trained in law as well as in psychology, draws from his large experience and accounts of the more publicized 'sex murders' in presenting many case histories of 'minor' as well as 'major' crimes, dividing the material on the bases of infantile sexuality, homosexuality, latent sexual deviations, and accidental sex offenses. He shows not only the background of this type of criminal, but the prognosis of what he might develop into and methods of curbing him. Statistics are presented, the increases not necessarily meaning that more such crimes are now being committed, but rather that there is greater publicity or a more thorough reporting of these misdemeanors. The book contains a few references in the foot-notes, but otherwise there is no bibliography.

LAND UTILIZATION IN CHINA. *A Study of 16,786 Farms in 168 Localities, and 38,256 Farm Families in Twenty-two Provinces in China, 1929-1933. In 3 Volumes. Vol. I, [Text]; Vol. II, [Atlas]; Vol. III, [Statistics].*

By John L. Buck. University of Chicago Press, Chicago. \$15.00 for the three Volumes. Vol. I, 9 x 6; Vols. II and III, 17½ x 12½; Vol. I, xxxii + 494 + 28 plates; Vol. II, xii + 146; Vol. III, xv + 473; 1937.

An important survey which was started over ten years ago. Its purpose was threefold; first, to train students in the methods of research in land utilization; second, to make available knowledge of China's agriculture, for its improvement, and as a basis of national agricultural policies; and, third, to make available to people of other countries interested in China's welfare certain elementary information about land utilization, food, and population in China." We regret that these volumes must be treated so briefly. Dr. John Lossing Buck, Professor of Agricultural Economics at the University of Nanking, directed the survey, was assisted by a large group of Chinese and a number of Americans. The work was first supported by the China Council and later by the International Research Committee of the Institute of Pacific Relations which appropriated, from funds given by the Rockefeller Foundation, a series of grants. Contributions to cover expenses of publication have been made by the National Economic Council, and the Central Bank of China.

The first of these volumes is divided into the following sections: Land, food and population; Physical factors; Man's use of the land; Marketing and prices; Population; and Standard of living. Throughout the text are 57 figures, 206 tables, 21 maps and 62 photographs. A detailed index is provided. The second volume (Atlas, with 179 maps and 20 figures and photographs) and the third (statistical data arranged in something over 300 tables), both in Chinese and English, are arranged so that they may be used independently or in conjunction with the first volume. Neither is indexed but the

tables of contents are sufficient in both cases for satisfactory reference work.



AFRICAN NOTEBOOK.

By Albert Schweitzer. Translated by Mrs. C. E. B. Russell. Henry Holt and Co., New York. \$2.00. 7½ x 5½; [6] + 144 + 9 plates; 1939.

In the year 1925, the author began to clear the forest and bush on the southern side of the broad-topped hill of Adolinanongo, on the banks of the River Ogowe above Lambarene in French Equatorial Africa, for the site of his new hospital: this was ready for occupation in January, 1927. It was at Adolinanongo that, in the seventies and eighties of the last century, there lived a young agent of the English trading firm, Hatton and Cookson, who later wrote his famous reminiscences of Africa under the pseudonym, Alfred Aloysius Horn—Trader Horn.

Dr. Schweitzer, world-famous as a medical missionary and musician, writes in his first chapter the fascinating history of the adventurous career of Trader Horn. Then the author proceeds to relate other tales of olden days, the part the present hospital plays in the lives of the natives, the many taboos and magic which affect the lives of the natives, and many anecdotes concerning the native nurses, patients, and visitors in the hospital. The author's most beautifully drawn character portrayal is that of *Oyembo* (the song), an African forest school-master who persuaded his villagers to rebuild their rotting huts, to clear their forest land in order to cultivate plantations of plantains, cassava, coffee, and cocoa for village and commercial consumption, to sell many rafts of logs to timber merchants, to organize village work and to set up book-keeping for accurate payment of services to the villagers, and, most important of all, to establish a school for both adult and child education. All this was accomplished by a native teacher and his villagers without government aid—an unusual thing in Africa where the natives permit the heavy, rank growth of forest vegetation to surround their very huts

and clear only enough plantation ground for bare subsistence.



MIGRATION AND ENVIRONMENT. *A Study of the Physical Characteristics of the Japanese Immigrants to Hawaii and the Effects of Environment on Their Descendants.*

By H. L. Shapiro. With the Field Assistance of Frederick S. Hulse. Oxford University Press, London, New York and Toronto. \$7.50. 9½ x 6½; xi + 594; 1939.

Since Boas's startling observations on the head shape of the descendants of immigrants, the question uppermost in the mind of students of the subject is what significance to attribute to the findings so much at variance with certain accepted anthropological dicta. A first real attack on the problem has been made by Shapiro who in this book summarizes the results of a well conceived investigation dealing with Japanese immigrants in Hawaii. He has had measurements taken on samples of (a) Japanese immigrants in Hawaii; (b) their relatives who have remained in Japan; and (c) their offspring born and bred in Hawaii. Analysis of the data shows first of all that the Japanese who have migrated differ in trunk, head and face measurements from their sedentary relatives in Japan and from their own offspring as well. After taking into account such factors as occupation, sex, age and place of birth the author is led to conclude that this sample of immigrants represents a distinct sub-group of the population from which it derives. It could be inferred then that in migratory movements there is also physical selection. The differences between the Japanese parents and their offspring born in Hawaii are regarded by the author as effects of the environment, particularly better economic conditions. The importance of this investigation both from the standpoint of results and of methodology cannot be emphasized too strongly. It initiates an anthropology of migration and should stimulate further studies in a field where knowledge is painfully inadequate. The author's exposition is

lucid and the statistical data are given in sufficient detail, the tabulations occupying almost two-thirds of the book.



THE MAROONS OF JAMAICA. *Anthropological Series of the Boston College Graduate School, Vol. 3, No. 4, Serial No. 12.*

By Joseph J. Williams, S. J. Boston College Press, Chestnut Hill, Mass. Subscription, \$3.00; Single copy, \$1.00. 9½ x 6½; 102; 1937 (paper).

The history of the Jamaica Maroons from the time of the arrival of Cromwell's soldiers in 1655 to the British Treaty of Peace with the Maroons in 1739 is outlined in detail in this monograph. Although it is believed by some that the Maroons of Jamaica are derived from the Arawak Indians, natives of Jamaica when the Spanish took over full occupation of the island in the early 16th Century, the author states that, contrary to this belief, the Maroons were primarily the African slaves of the Spanish who led these slaves to the mountains and established them there "... as a menace against Cromwell's soldiers after the latter had conquered Jamaica in 1655." Thereafter, the English imported their own slaves. Among these were the warlike, rebellious Ashanti, who chafed at English bondage and escaped to the mountain fastnesses of the Maroons. There the powerful Ashanti gained complete control and introduced their language and the divine worship of Nyankopon into the Maroon culture. In the early part of the 18th Century, about 1730, the appellation Maroon was extended to include the Ashanti as well as the original Spanish slaves.

The author has drawn heavily on the *Journals of the Assembly of Jamaica, 1709-1731*, and the *Acts of Assembly Passed in the Island of Jamaica, from 1681 to 1737 inclusive*, for the source material of this interesting study of the early conflicts between the British settlers and the Maroons.

An additional article by I. E. Thompson on the *Maroons of Moore Town* throws interesting light on the nature and customs of the present day Maroons.

TRIAL OF FIELD AND GRAY.

Edited by Winifred Duke. William Hodge and Co., London and Edinburgh. 10s. 6d. 8½ x 5½; vi + 302 + 9 plates + 1 folding chart; 1939.

This latest addition to the *Notable British Trials Series* (Vol. 67) is not quite up to the best, or perhaps even the usual, standards of that series. This is not because of any lack of thoroughness and competence on the part of Winifred Duke, the editor of the volume, but essentially because the case itself was a dull and stupid one. The completely idiotic behavior of Field and Gray, which would be incredible if it had not actually happened, brought about their prompt conviction almost automatically. Probably police and prosecution have rarely had an easier task in all the annals of crime than they had in this case. Two men, well known in a seaside resort, pick up a strikingly good looking girl from London taking her annual holiday; parade her along the main street in early afternoon of a summer day, meeting numbers of their friends and acquaintances along the way; and then proceed to beat her to death in mid-afternoon at a spot on the beach only a quarter of a mile away from a group of men with whom they had talked a few minutes before in passing, and practically in full view of a row of cottages less than a half mile away and on higher ground overlooking the beach. They then buried the body where it fell on the beach, and did this so inadequately that one foot was sticking out and tripped a small boy playing there next day. After this performance the two murderers sauntered home, and continued their normal habits of life in the town.

Enough has been said to indicate that this case really belongs to Ripley's *Believe it or Not* rather than to *Notable British Trials*.



THE SOUTHERN BANTU.

By L. Marquard and T. G. Standing. Oxford University Press, London, New York and Toronto. \$2.50. 7½ x 4½; vii + 262 + 2 folding maps; 1939.

A worthy addition to the rapidly growing literature on race relations between the

ever-encroaching whites and the native peoples of Africa, this book explains the economic, political, social, educational, and religious life of the Bantu prior to and succeeding the European scramble for territory in South Africa. The greater part of this book deals with a study of the devastating effects of European invasion of Bantu territory in the Union of South Africa. The detribalizing and demoralizing effects on the Bantu at work in the mines and towns of the Union are discussed. In addition to a study of conditions in the Union, Bantu life in Southern Rhodesia, in the three Protectorates—Basutoland, Bechuanaland, and Swaziland, and South West Africa is presented in lesser detail.

A very clear picture is given of the chaos caused in the old tribal customs of the Bantu by European encroachment on and acquisition of land on which the Bantu had formerly lived in tribal groups as cattle owners and tillers of the soil. The economic problem, therefore, as well as antagonizing social and legal inequalities, prompts the Bantu to dislike the European as thoroughly as the European dislikes and misunderstands the Bantu. The authors believe that a thorough understanding of the early life of the Bantu prior to the European entrance on the scene will bring about a more sympathetic attitude on the part of the European to the present difficulties of the adjustments made necessary in the lives of the Bantu natives of South Africa. This is an excellent book for the promotion of better race relations.



LES TYPES HUMAINS. *Première Partie. Les Types Somatiques. Raciaux—Morphologiques—Constitutionnels. Deuxième Partie. Les Types Psychologiques. Tempéraments—Caractères—Types d'orientation générale de l'esprit—Types psychanalytiques—Types réflexologiques — Types psychosociologiques. Troisième Partie. Les Types Somatopsychiques. Variétés neurovégétatives. Constitutions somatopsychiques. Biotypes et variétés endocrinologiques. Types criminels. Actualités Scientifiques et Industrielles, 495, 496,*

497. *Biologie du Travail et Biotypologie*, III, IV, V.

By Eugene Schrieder. Hermann et Cie, Paris. Parts I and III, 20 francs each; Part II, 18 francs. 10 x 6½; Part I, 104; Part II, 79; Part III, 105; 1937 (paper).

The purpose of these three publications is to review the principal methods of classification of body types and the results of investigations on the relationship between somatic structure and psychic behavior. The first volume surveys rapidly the morphologic types as defined by various workers from Manouvrier to Tschernorutzky. In greater detail are presented the views of the French and Italian schools of constitutionalists. The author concludes that the rather complicated index of Viola is the most adequate to describe metrically the characteristics of the physique. In the second volume Schrieder examines the classifications of psychological types as viewed from the standpoint of psychoanalysis, clinical psychiatry, endocrinology and of the various schools of psychology. He finds that the several classifications have few elements in common and therefore they are not strictly comparable. In the third volume he brings together the threads of the preceding volumes and discusses the relationship between physique and psyche with emphasis on the studies of Kretschmer, Jaensch and of Pende. Included here is also a chapter on criminal types. The main conclusion reached is that more and careful work is necessary before a definitive idea can be had of the significance and degree of the somato-psychic correlations observed. The author has made painstaking efforts to be clear and thorough even if brief and as a result this is a valuable work for the student of the subject.



CAUSES OF CRIME. *Biological Theories in the United States 1800-1915.*

By Arthur E. Fink. University of Pennsylvania Press, Philadelphia; Oxford University Press, London. \$3.00. 9 x 6; xi + 309; 1938.

This historical survey of the anthropological, psychological and genetic theories on the causation of crime is purposely and

mainly dedicated to the American students of these aspects of criminology. The author covers the period from 1800 to 1915 beginning with Rush, to whom is given credit for emphasizing the relation of crime to psychopathology, down to Healy, the foremost exponent of the study of the personality of criminals. In between these periods criminological thought has been concerned with phrenology, the concepts of Lombroso on the criminal man, eugenics, and the relation of crime to mental deficiency. From the impact of these ideas have resulted numberless viewpoints which vary from a complete denial of the existence of an environmental factor in the causation of crime to the acceptance of the influence of both nature and nurture. It is obvious from this survey that the majority of theories that have been advanced have very little if any factual foundation and as a matter of fact also lack originality, so that one cannot really speak of an American School of Criminology. In addition, none of the theories has been effectual in establishing criminology on a solid scientific basis. This failure may be largely due to the fact, which the author does not mention, that this country has had more than its share of sentimental penologists. These, incidentally, should also be enumerated among the causes of crime. The book is well written and very interesting. Its one real flaw derives from the author's attitude which is not sufficiently critical and from his desire to present the views in vogue here without too much reference to their foreign origin. This disembodiment has the consequence of distorting the picture of the theoretical developments considerably. There is an index and an ample bibliography.



THE MICROBE MAN. *A Life of Pasteur for Young People.*

By Eleanor Doorly. Introduction by Pasteur Vallery-Radot. Woodcuts by Robert Gibbings. D. Appleton-Century Co., New York and London. \$1.50. 8 x 5½; xiii + 160; 1939.

In her delightful book *The Insect Man*, Miss Doorly displayed her rare talent for writing stories, concerning great men of

science, which are both scientifically and biographically correct, and at the same time interesting and readable to the children for whom they are intended. The present volume is well up to the high standard set in the earlier work, and the author is to be congratulated for her fine achievement.

The story of Pasteur's life is unfolded as the author visits the places where he lived and worked, and talks with the people who knew and loved him. The delightful style and the interesting subject matter of the book are well illustrated in the following excerpt (pp. 159-160):

"No one who died was ever so alive among us as Louis Pasteur. You meet pasteurized milk on any doorstep, and, if you have any imagination, you see his delightful face looking out at you from the mighty pasteurizing plant of all the dairies of the world, watching over your safety. Every dog you meet wags his tail and smiles at the thought that no one need fear a mad dog any more, because such things have ceased to be. In the sunny mountains, any old silkworm breeder will say to you: 'Pasteur saw to it that we never lose our worms.' In every chicken run, the hens; in every field, the lazy cows and sheep and pigs say the old bad days are over.

The woodcuts by Mr. Gibbings make a worthy contribution to the excellence of this pleasant volume.



THE NATIVE RACES OF AFRICA AND MADAGASCAR. *Anthologia Anthropologica*. A Copious Selection for the Study of Social Anthropology from the Manuscript Notebooks of Sir James George Frazer.

By Sir James G. Frazer. Arranged and Edited by Robert A. Downie. Percy Lund, Humphries and Co., London. 35s. net. 11 x 8½; xii + 578; 1938.

Sir James Frazer early began the practice of extracting from his readings all those passages which in any way pertained to the social or religious life of primitive peoples. The book, of which the present volume

is the first instalment is in essence an epitome or rather an anthology of Social Anthropology. When I first addressed myself to that study more than fifty years ago I made a practice of noting in a book the passages of authors which seemed to me of particular significance in their descriptions of the manners and customs, the beliefs and practices, of the various races of men, especially of those races of backward

culture, an understanding of whom is of special importance for a knowledge of our race. In course of time these notebooks multiplied, and it is their contents which I now wish to lay before the reader.

The volume before us, dealing only with the native races of Africa and Madagascar (something over 200 separate peoples) contains a wealth of material mostly extracted (quoted verbally) from English books but not infrequently from French and German works. Very little of this material has appeared in Sir James Frazer's published writings. It begins with the primitive Bushmen and Hottentots of South Africa and proceeds northward to the ancient Egyptians and then to the island of Madagascar. The reader "will hear little or nothing about the higher cultures of Dutch, English, Portuguese, Belgian, French, and Italian origin, which from time to time have been superimposed on the indigenous population by European immigrants in many parts of the continent." Outline maps indicate the territories of the chief races and the index adequately covers the 550 pages of text.



ECONOMICAL ADMINISTRATION OF HEALTH INSURANCE BENEFITS. *Studies and Reports*. Series M (Social Insurance) No. 15.

International Labour Office, 734 Jackson Place, Washington, D. C.; P. S. King and Son, London. \$1.75. 9½ x 6½; vii + 332; 1939.

ECONOMICAL ADMINISTRATION OF HEALTH INSURANCE BENEFITS. Part I. *The Principle of Economy in the Administration of Health Benefits*. (Extract from the volume published under that title in "Studies and Reports," Series M, Social Insurance, No. 15.)

By Walter Pryll. International Labour Office, Geneva. \$1.75. 9½ x 6½; iv + 137; 1938 (paper).

The purpose of this report is to draw attention to the medical task of compulsory social insurance institutions and to study in particular the problem of applying the principle of economy to the medical and pharmaceutical benefits of sickness insurance funds. Part I of the volume analyzes in a very broad way the duties of the social

insurance practitioner and deals with the principle of economy in diagnostic, therapeutic and prophylactic activities. This part written by Walter Pryll, a former medical adviser of the Berlin Local General Sick Fund, is also published separately (see the second of these publications listed). Part II of the volume is a useful collection of information containing an analysis of the laws, regulations and principles of social insurance measures in force in seven countries, namely Czechoslovakia, France, Germany, Great Britain, Hungary, Poland, and Yugoslavia. Part III gives an account of the conclusions adopted on the subject of economical treatment and prescribed by some international bodies such as the International Labor Office, the International Medical Association, the International Conference on Social Insurance and Mutual Aid.



THE CZECH CONSPIRACY. *A Phase in the World-War Plot.* Second (Enlarged) Edition.

By George Lane-Fox Pitt-Rivers. Boswell Publishing Co., London. 3s. net. 8½ x 5½; 93 + 8 plates; 1938.

The author, an eminent British ethnologist, outlines briefly the 20 year old history of the Czech Republic from the time of Masaryk and the famous self-determination policy to the signing of the equally famous Munich Pact; states his view of the causes of the 1938 Czech Crisis; justifies the Munich Pact; and, in general, presents the side of the Czech story that the newspapers and periodicals of England and the United States ignore, namely that of alleged Czech terrorism in German Sudetenland. Captain Pitt-Rivers discusses the low social status, great unemployment, poor housing and sanitary conditions, and general mass depression of the 3½ million Sudeten Germans under Czech Rule. Included in this study are population statistics on the diverse racial groups in Czechoslovakia. These figures indicate that the policy of self-determination was accepted after the World War as a happy solution to the weighty problem of the most effective way in which

to weaken Germany in Central Europe and to break up the Austro-Hungarian Empire. The author believes that the Munich Pact does nothing more than rectify the injustices brought about by the so-called self-determination of the Peace Treaty and "that real friendship and co-operation between Great Britain and Germany are essential to the establishment of enduring peace not only in Western Europe but throughout the world. . . ."

This book, however, went to press November 15, 1938, four months before the coup of March, 1939, involving the non-German peoples of Czechoslovakia.



SOCIAL ECOLOGY. *A Critical Analysis.*

By Milla A. Alihan. Columbia University Press, New York. \$2.75. 8½ x 5½; xiii + 267; 1938.

The ecological school of thought in sociology results from the efforts of R. E. Park and E. W. Burgess, who, borrowing biological terminology, have set as their objective to study the 'relationships of symbiosis, or the factors involved in living together, independent of communication' (p. 11) or, as stated elsewhere, 'the spatial and temporal relations of human beings as affected by the selective, distributive, and accommodative forces of the environment' (p. 9). In the pursuit of these objectives a group of social scientists centering around the University of Chicago are actively engaged today and in truth have contributed much factual information to various sociological questions. The author, who is obviously not of the group, has undertaken to examine critically the theoretical principles underlying the ecologist's standpoint, particularly his concept of person, social organism, community and society. In addition the author examines a few of the theories of the authorities on which Park and his school lean heavily. The result of this critical study is to show rather clearly that, to put it mildly, there exists some confusion as to what the ecologists are really driving at and what is the actual meaning of the terms bandied

about so readily. Alihan's arguments are rather sound and persuasive. The author manifests admirable self-restraint in avoiding the irony and sarcasm one would be tempted to adopt in this case and really demonstrates an unusual insight into the logical requirements of the subject.



KARL PEARSON. *An Appreciation of Some Aspects of His Life and Work.*

By E. S. Pearson. *The University Press, Cambridge; The Macmillan Co., New York.*
\$3.75. 10½ x 7½; viii + 170 + 9 plates; 1938.

It is difficult for a son to write a biography of his father. This is partly because he is too close to his subject to view it in perspective, but chiefly because a son remembers so many intimate details that a sense of delicacy precludes sharing with the public, even if, indeed, the public wishes to share them. In this instance the son has shown remarkable taste in his selection of material. He has not attempted an exhaustive biography; rather he has pictured a personality, a smaller but frequently a more difficult task.

Karl Pearson was a many sided genius. This is evidenced by the advertisement on the cover of this book in which are listed works from his pen dealing with such divers subjects as death rate, the life of Galton, and the portraiture of Jesus Christ and Oliver Cromwell. And it must be remembered that the same mind that computed the *Tables for Biometricians and Statisticians* also produced a *Passion Play*. Such minds were not uncommon in the days of Leonardo da Vinci, Michelangelo, and Zarlino, but the post-renaissance period has been one of specialization, and intellects of this type are now few and far between. But Pearson was also a human being—a fact not always appreciated by those who know him only by his formulae. It is the human Pearson that his son introduces in this book, and who speaks again from its pages, this time to a wider audience of those who were not privileged to know him in the flesh.

EDMUND BURKE AND HIS KINSMEN. *A Study of the Statesman's Financial Integrity and Private Relationships. University of Colorado Studies. Series B. Studies in the Humanities. Vol. 1, No. 1.*

By Dixon Wecter. *University of Colorado, Boulder.* \$1.00. 10 x 7; 113; 1939 (paper).

Edmund Burke has been the subject of not a few biographies, interest in him being stimulated not only by his unique personality but also by the mysteries which surround his life, particularly in relation to religion and finances. It is on the latter topic that the author has focussed his attention. Aided by documentary relics he seeks to piece together the available information about the financial troubles directly involving certain of Burke's kinsmen and indirectly Burke himself through his relationship and his strenuous defense of their obvious misdeeds. When the facts are ordered, Burke's participation in the frauds committed by his brother and alleged cousin is not certain beyond a reasonable doubt. However, he could not have been ignorant of their acts and so, legally speaking, was really an accomplice. All things considered, the author suggests that Burke's overt attitude might have been the consequence of strong familial attachment and the everlasting ambition to rise as far as possible above his humble origin. This charitable viewpoint seems to receive adequate support from the data at hand and the author is to be complimented on the order which he gives to the accumulated facts and on the scholarliness he demonstrates. This touches on the pedantic sometimes, especially through the continuous use of footnotes. Had they been avoided the monograph, interesting as it is, would have made for enjoyable reading.



SOUTH WEST AFRICA IN EARLY TIMES. *Being the Story of South West Africa up to the Date of Maharero's Death in 1890.*

By Heinrich Vedder. *Translated and Edited by Cyril G. Hall. Oxford University Press, New York and London.*

\$6.00. 8 $\frac{3}{4}$ x 5 $\frac{1}{2}$; xv + 525 + 9 plates + 2 folding maps; 1938.

A detailed history of South West Africa up to 1890 which has been compiled from a vast number of individual records of both natives and Europeans—old reports, letters, and diaries collected in the twenty-eight volumes of the *Sources of the History of South West Africa*. From these records and from German literature on the subject, the author has drawn a comprehensive picture of South West Africa from the time of early explorations up to 1890, when the history of early South West Africa ends. The author is preparing a subsequent volume on German South West Africa.

Of particular interest in this historical and ethnological study is the vivid picture of the political, economic, social, educational, and religious life of the many African races in the country. The author tells also of the many feudal wars between the Namas, Afrikaners, Hereros, Orlams, and other tribes for power and grazing land in a country which is largely barren. To the South West Africans cattle meant wealth but cattle also meant fair grasslands. Therefore, the history of this part of Africa is of a constant tug of war between tribes for grazing land.



MORPHOLOGIE SOCIALE.

By Maurice Halbwachs. *Librairie Armand Colin, Paris*. 17 francs 50 (cloth); 15 francs (paper). 6 $\frac{3}{4}$ x 4 $\frac{1}{2}$; 208; 1938.

This is an exposition of certain aspects of human social behavior along the directives laid down by Durkheim for whom the facts generally studied in demography express the morphology of the social structure, the concrete results of social interrelations. In the first section of the booklet the author illustrates this viewpoint by considering religion, politics and economics. He utilizes, as an example, some unique data on church attendance in France to discuss the declining trend in the religious behavior of the French population in terms analogous to those adopted in the study of population—births, deaths, density, etc. A similar

procedure is followed in the examples regarding political behavior and industrial and commercial conditions. In the second section of the book the author examines the strictly vital statistics, the state and movement of the population of France and other countries, but always with emphasis on their significance as end results of social interactions. The author reaches no new conclusion but the sober discussion and clear exposition of the subject given here will be useful to an understanding of the sociological approach to demography.



THE NOBEL PRIZES AND THEIR FOUNDER ALFRED NOBEL.

By Fritz Henriksson. *Alb. Bonniers Boktryckeri, Stockholm*. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; 59; 1938 (paper).

In this little paper Henriksson has given a brief account of the genealogy of the Nobel family, and as complete a biography as is available of Alfred Nobel, founder of the Nobel prizes. The great chemist left, at his death, a fortune which amounted to nearly 9 million dollars. In his will, he made provisions for the awarding of the five annual prizes; one in chemistry, one in physics, one in physiology or medicine, one in literature, and one in the field of international fraternity, or world peace. The democratic spirit of the will is shown in Nobel's declaration "... that, in the awarding of prizes, no consideration whatever be paid to the nationality of the candidates, that is to say, that the most deserving be awarded the prize, whether of Scandinavian origin or not."

The paper contains also a list of Nobel prize winners since 1901. Several photographs depicting the pomp and ceremony attached to the awarding of the prizes are included.



UNSOLVED MYSTERIES OF THE ARCTIC.

By Vilbjalmur Stefansson. *Introduction by Stephen Leacock. The Macmillan Co., New York*. \$3.50. 8 $\frac{3}{4}$ x 5 $\frac{1}{2}$; xi + [7] + 381; 1939.

This entertaining volume discusses five Arctic "mysteries"—the disappearance of the colony of Europeans set up in Greenland around 985 A.D.; how Sir John Franklin's expedition including more than a hundred persons managed to die to the last man in the midst of relative plenty; the strange fate of Thomas Simpson; how Andrée died; and the case of the missing Soviet fliers.

As is to be expected from its distinguished author, the book is written with great clarity and charm. The tentative solutions of the mysteries are logical, and persuasive because of their logic. It is difficult to avoid the conclusion that Stefansson has the right answers. The documentation is extensive and critical. In fact the whole production may be said to adorn the rigors of sound historical scholarship with the charm of good literature.



VIKINGS OF THE SUNRISE.

By Peter H. Buck. Frederick A. Stokes Co., New York. \$3.50. 8½ x 5½; xiii + 335 + 31 plates; 1938.

"Polynesian Romance" or "The Heritage of the Polynesians" may well have been used as the title of this fascinating story. The author, himself half Polynesian, has traced the ancestry of the people of the Pacific Isles from the earliest great seafaring race from the Asiatic mainland down to the present Polynesian, Melanesian and Micronesian groups. He has made use of ancient folk lore as well as the present geographic distribution of anthropologic and linguistic types in presenting this interesting discourse. Buck's thorough personal acquaintance with the island groups, and his ability to hold their confidence and good will in the collecting of anthropometric data on some 2500 living people from representative parts of Polynesia, have well qualified him for such an undertaking.

The text is interestingly written and is well supplied with illustrations of representative peoples, landscapes, and artifacts of the island groups. The volume contains a bibliography and an index.

CRIME AND PUNISHMENT IN EARLY MARYLAND.

By Raphael Semmes. The Johns Hopkins Press, Baltimore. \$3.00. 9 x 6; [8] + 334; 1938.

A most interesting history of the lives of the seventeenth century Maryland colonists by the author of *Captains and Mariners of Early Maryland*. In this volume Semmes treats in a scholarly fashion, and with considerable humor, the numerous crimes and so-called crimes of this period which together give a rather complete picture of the domestic lives of the people. Ten chapters discuss every conceivable offence from mere hog stealing and profanity to assault, homicide, and adultery. Other chapters discuss housing and clothing, and servants and their discipline and punishment. A final chapter deals at length with the treatment given the sick during the seventeenth century and also mentions some of the customs observed at burials.

All statements made in the text are supported by citations at the back of the book most of which refer to volumes of the Archives of Maryland. Frequent quotations from old court records give added interest to the author's most readable volume. There is both an index of topics and of persons.



THE STANDARD OF LIVING IN BRISTOL. A Preliminary Report of the Work of the University of Bristol Social Survey.

By Herbert Tous. J. W. Arrowsmith, Bristol. 1s. net. 8½ x 5½; 64; 1938 (paper).

A preliminary report of certain aspects of a more comprehensive social survey of Bristol which is nearing completion. "This report is concerned only with incomes which fall below middle-class levels, and consequently it covers four-fifths of all Bristol families. Its purpose is to study the standard of living in Bristol. How many families just exist and how many live?" Of the total group it is estimated that 12,000 families are very comfortable; 56,000 families are just ordinary; 21,000 families "not in poverty but whose lot is far from comfortable"; and 11,000 families in poverty.

The tabular matter is presented in the text and in the three appendices.



DR. IDA: INDIA. *The Life Story of Ida S. Scudder.*

By Mary P. Jeffery. Fleming H. Revell Co., New York, London and Edinburgh.

\$2.00. 8 x 5½; 212 + 10 plates; 1938.

This is the life story of Ida S. Scudder, president of the Medical College for Women, Vellore, India, a medical missionary in India since the turn of the century. The material for the book was collected by Dr. Mary Pauline Jeffery, one of Dr. Scudder's colleagues, and was prepared for publication by Lucy W. Peabody of Beverly, Massachusetts. Dr. Scudder's chief work naturally was with the women of India and we are given many glimpses of the customs and superstitions with which she had to cope in her treatment of her patients. In addition there are stories and anecdotes of many other phases of Indian life. A chapter on caste, one on untouchables and on roadside dust give the book added interest.



VERNON KELLOGG 1867-1937.

Belgian American Educational Foundation. Anderson House, Washington, D. C. 9½ x 6½; xi + 160; 1939.

This beautiful volume is a worthy tribute to the memory of a distinguished biologist, who played a broader role on the world stage of his time than most scientific men ever do. His life's work influenced the course of human affairs in ways that were good and effective far beyond the conventional boundaries of science. A clear-headedness that was Gallic in its simplicity and directness combined with a boundless buoyancy of spirit and genius for friendship to make Vernon Kellogg's life truly a benefaction to his fellow men.



RASSENKUNDE UND RASSENGESCHICHTE DER MENSCHHEIT. *Erster Band. Die Forschung am Menschen. Sechste Lieferung (Bogen 40-47). Zweite umgearbeitete und erweiterte Auflage.*

By Egon Frbr. von Eickstedt. Ferdinand Enke Verlag, Stuttgart. RM. 9.20.

10½ x 7; 625-752; 1938 (paper).

Previous issues of this second edition (with the exception of *Lieferung 5* which has not yet been published) have been noticed in these columns (Numbers 1 to 3 in Vol. 13; No. 3, and Number 4 in Vol. 14, No. 1). This number treats the structure and developmental processes of body form and its abnormalities.



A GRAPHIC SUMMARY OF AGRICULTURAL CREDIT. U. S. Department of Agriculture. Miscellaneous Publication No. 268.

By Norman J. Wall and E. J. Engquist, Jr. Government Printing Office, Washington. 10 cents. 9½ x 5½; ii + 48; 1938 (paper).

This is one of a series of ten graphic summaries dealing with American agriculture. Maps and diagrams clearly depict the distribution of farm mortgages, loans, and banking activities. The time period covered is in large part up to and including the year 1937.



ZOOLOGY

DIE BIOLOGIE DER EUROPÄISCHEN IGL. *Monographien der Wildsäugetiere, Band V.*

By Konrad Herter. Verlag Dr. Paul Schöps, Leipzig. RM. 10.80 (paper); RM. 12 (cloth). 9½ x 6½; [6] + 222; 1938.

This monograph on the European hedgehog is so full of interesting material that one hardly knows where to begin to review it. Its anatomy, geographic range, natural history, and behavior, and the systematics of the genus are all recorded from a careful review of the literature and the personal observations of the author. Included in the natural history section are the animal's ecological habitats, its breeding activities, growth, enemies, diseases, etc.

This little animal has always attracted the attention of the layman and records of it abound in folklore and poetry. We are sorry to learn that some of its quaint habits are severely discredited by the

author, especially the one concerning the habit of carrying fruit on its quills. That the hedgehog is a depredator of chicken eggs is shown to be a fallacy although it will eat small birds' eggs, but not by natural instinct. Its fame as a mouse hunter is likewise not accepted with much favor by the writer.

A bibliography and several plates of photographs and charts help to make this volume an important contribution to the biology of one of Europe's most characteristic mammals.



MARVELS OF THE INSECT WORLD.

By Jean-Henri Fabre. Edited, Annotated, and Translated by Percy F. Bicknell. Illustrated by Robert Gibbings. D. Appleton-Century Co., New York and London. \$2.50. 8 x 5½; xii + 239; 1938.

This is an excellent translation of one of the numerous scholarly works of the world famed naturalist, Jean-Henri Fabre. The work begins with an elementary consideration of insects in general, and then proceeds through many of the well-known orders, giving detailed discussions about the natural history, habits of reproduction, instincts, and economic value of the different forms. The detail and accuracy of Fabre's stories about insects indicate that he was a naturalist of the first order, and that he justly deserves the titles "an inimitable observer" and "the insect's Homer" given him by Darwin and Maeterlinck, respectively.

The wood-cuts by Mr. Gibbings are quite up to the standard set in Doorly's *The Insect Man* and *The Microbe Man*.



THE WATCHER AT THE NEST.

By Margaret Morse Nice. The Macmillan Co., New York. \$2.00. 8½ x 5½; [12] + 159; 1939.

Even more interesting than her *Life History of the Song Sparrow* is Mrs. Nice's *The Watcher at the Nest*. The enthusiastic interest in her feathered pals, and her ability to make a presentation which actually reveals personality in birds, has made this book an extremely valuable contribution to the field of ornithology.

A large portion of the volume is devoted

to a discussion of the activities of several individual birds; their migrations, matings, broods, songs, and personal characteristics. The study required some eight years of patient and painstaking observation and many hours of desk work in interpreting those observations.

The latter portion of the book is devoted to discussions on the activities of cowbirds, warblers, vireos, mourning doves, herons, quails, and numerous other birds that came under the author's observation while she was making detailed studies on the song sparrow. Whenever the opportunity presents itself, Mrs. Nice makes an earnest plea for the preservation of weeds and brambles and all the other forms of shelter and sources of food that are rapidly being cleared away to satisfy man's selfish interest in becoming more and more civilized.



THE UNDERWATER ZOO.

By Theodore McClintock. The Vanguard Press, New York. \$1.75. 8 x 6; ix + 111; 1938.

This book is developed around the building and maintaining of a home-made fresh water aquarium. McClintock writes in a delightful style, and the exciting drama of his underwater zoo should stimulate countless boys and girls to develop a similar project within their homes. The text is entirely void of any scientific terms and discussions, and at the same time it presents a lot of keen scientific observations.

Some of the illustrations might be criticized by scientific artists, but they fully answer their purpose in adding charm to this pleasant little volume. The last chapter presents plans for building an underwater zoo, and gives an excellent list of texts to be used in identifying, classifying, and studying the natural history of the forms most likely to be encountered in the development of such an enterprise.



TROUT STREAMS. *Conditions that Determine Their Productivity and Suggestions for Stream and Lake Management.*

By Paul R. Needham. Comstock Pub-

Issuing Co., Ithaca. \$3.00. 9 x 6; x + 233; 1938.

The conservation of our North American trout through the development and care of the fresh-water streams suitable for their existence has engaged the attention and whole hearted activity of many private, as well as many government institutions for the past two decades. There has been a real need, not only for trout conservationists and sportsmen but for the general lay population as well, of a comprehensive treatment of the natural history and the economy of the trout of our North American streams. Needham's long field experience well qualifies him for the task of fulfilling this need.

Such topics as stream conditions, composition and distribution of the trout's food supply, and lake and stream management are thoroughly and interestingly discussed. Several sections dealing with the taxonomy of trout, and instructions for field surveys have been appended to the original text. A bibliography of some 140 titles and an index conclude the volume.



ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Volume XXIII, Part 4, Numbers 17-21.*

New York Zoological Society, Zoological Park, New York. \$1.15. 10½ x 7; vii + 319-405; 1938 (paper).

The following papers are listed in Part 4 (nos. 17-21) of this publication: (1) The phylogeny of the characin fishes, William K. Gregory and G. Miles Conrad. This paper is well illustrated with 37 line drawings, gives a pictorial classification of the characins, and a bibliography of 52 titles; (2) Eastern Pacific Expeditions of the New York Zoological Society. XVI. Holothurians from the western coasts of Lower California and Central America, and from the Galápagos Islands, Elisabeth Deichmann (15 text-figures; bibliography, 53 titles); (3) A note on eggs and young of *Leishanodon madagascariensis* (Duméril and Bibron), Roger Conant (1 plate); (4) An unusual aberrantly colored Pleuronectid, C. M. Breder, Jr. (1 plate); (5) A diagnostic test for the recognition of tuberculosis in Primates;

a preliminary report, Charles R. Schroeder (2 plates); (6) Index to Volume 23.



A CATALOGUE OF VERTEBRATES OF JAPAN.

By Yaichiro Okada. Maruzen Company, Tokyo. \$3.00 in U.S.A.; 12s. in Europe. 9½ x 6½; iv + 412; 1938.

The writer has compiled a catalogue of 3823 vertebrates to be found in Japan and neighboring islands. This list has been derived from previously published faunal lists and apparently the writer has not undertaken to vouch for their accuracy but accepts them without comment. The value of the book would have been greatly increased had references to the original descriptions of the various forms been included. It is also unfortunate that the classification of the Aves is based on a rather unique system and does not follow the now generally accepted arrangement of Wetmore.

However, the list does give an indication of the vertebrate fauna of Japan and should be of value to the zoogeographer as well as the taxonomist. There is an index to generic and specific names.



DIE SEIDENSPINNER. *Ihre Zoologie, Biologie und Zucht. Technologie der Textilfaser, Band VI, Teil 1.*

By Fr. Bock and L. Pigorini. Verlag von Julius Springer, Berlin. RM. 16.80. 9½ x 6½; vii + 171; 1938.

This is an excellent brief description (with 144 illustrations) of the morphology, histology, development, physiology and diseases of the silk-worm. Most of the discussion concerns the common *Bombyx mori* L. although other silk producing organisms, such as *Bombyx fortunatus*, *B. arracanensis* and *Antberaea yamamai* are not ignored. The book begins with a brief review of the history and present status of the silk industry in Europe, Asia, and the United States. L. Pigorini contributes a chapter (translated into German by the senior author, who has also written the rest of the book) on the culture of the silk-worm. The author expresses the hope that this book will help to stimulate a new interest, in

Germany and other European countries, in the production of real silk.



SPECKLED NOMADS. *A Tale of Trout in Two Rivers.*

By H. E. Towner Coston. *The Macmillan Co., New York.* \$3.00. 7½ x 5½; 299 + 32 plates; 1939.

The lowlands of England and the rugged expanses of New Zealand are settings for the biographies of two trout. The author is a keen observer of nature and writes his story in a charming style. However, he does not sacrifice biological fact to wild speculation, despite the gaps in our scientific knowledge of fish behavior. Vivid descriptions of encounters between man and fish reveal the thrill that Mr. Coston feels in the screaming reel and the bent rod. Yet never is the value of conservation overlooked. Methods are shown whereby the fish are protected not only from unscrupulous anglers, but also from the depredation of birds and aquatic denizens who prey on egg, alevin, or small fry. This volume, like *Beneath the Surface* (cf. Q.R.B., 1938) contains many interesting and attractive illustrations.



DIE TIERISCHEN PARASITEN DES MENSCHEN.

By Walter Stempell. *Verlag von Gustav Fischer.* RM. 12. (paper); RM. 13.50 (cloth). 10½ x 6½; viii + 226; 1938.

The systematic order of this monograph on animal parasites of man, written by an experienced zoologist, is very useful. It will contribute especially to the knowledge of medical students and physicians concerning parasites, and is illustrated with a great many fine and distinct drawings, made mostly by the author himself. All the descriptions given of the single species are short and concise, emphasizing in particular their meaning as parasites of man. There is a complete subject index.



SHARP EARS, THE BABY WHALE.

By John Y. Beary. *Illustrated by Helene Carter.* J. B. Lippincott Co., New York,

Philadelphia and Toronto. \$2.00. 8½ x 8½; 107; 1938.

Delightfully told, in a clear and crisp style, the story of the adventures of a baby whale should prove of interest and amusement to children of all ages. Following the amazing adventures of our hero in his five-year trip around the world, one incidentally acquires quite a store of information concerning the strange marine world and its inhabitants in general, and whales in particular. In addition, a smattering of geography is thrown in. Among Helene Carter's delightful illustrations is included a pictorial map of the world showing Sharp Ears' course and the places in which his various adventures befell him.



THE BRITISH MOSQUITOES.

By J. F. Marshall. *British Museum (Natural History), London.* 20s. 10 x 7; xi + 341 + 20 plates; 1938.

This is an elaborate description of the 29 species of mosquitoes (Culicinae) that have so far been found in Britain. The eggs, larvae, and adults, as well as their life history and ecology are described in detail. Numerous figures and color plates, keys to adults and larvae, make this volume invaluable to medical and economic entomologists. Several chapters are devoted to malaria and malaria control in Britain, as well as to the biology of mosquitoes in general.



MOO-WEE, THE MUSK-OX.

By Jane Tompkins. *Illustrated by Kurt Wiese.* *Frederick A. Stokes Co., New York.* \$1.50. 8½ x 6½; xi + 103; 1938.

The author is familiar with the Arctic and has produced the kind of book for children (from six to eight years) that is not only entertaining but is also authentic in detail. Moo-Wee's life is made interesting and exciting by the many kinds of Arctic animals which the author introduces into her story, as well as the little Eskimo boy with whom the baby musk-ox lives for a while. The drawings, by Kurt Wiese, are delightful and the

large clear type makes the book easy to read.



A CONTRIBUTION TO THE BIOLOGY OF NORTH AMERICAN VESPINE WASPS. *Stanford University Publications, University Series. Biological Sciences, Volume VIII, Number 1.*

By Carl D. Duncan. *Stanford University Press, Stanford University, Calif.; Oxford University Press, London.* \$2.50 (paper); \$3.25 (cloth). 10 x 7; 272; 1939.

One half of this work is devoted to the morphology and taxonomy of North American wasps belonging to the genera *Dolichovespula*, *Vespula*, and *Vespa*. The remainder is a critical review of the life history of these insects with the author contributing his own observations. 54 plates, an index, and a bibliography make this a handsome addition to the subject of entomology.



ANIMAL ECOLOGY. *Second Edition.*

By A. S. Pearse. *McGraw-Hill Book Co., New York and London.* \$5.50. 9 x 6; xii + 642; 1939.

The first edition of this treatise on animal ecology has been reviewed in these pages (Vol. 1, No. 4). The present text has been completely revised, seven new chapters added, and the bibliography greatly enlarged. A previous criticism of this book mentioned its lack of illustrations; the new edition now contains many photographs and drawings.



AMERICAN ANIMAL BOOK.

By Philip L. Martin. *Alfred A. Knopf, New York.* \$1.75. 9 x 6; [36]; 1938. This picture book of animals consists of illustrations of 32 wild animals of America. The drawings themselves are simple and accurate and might easily appeal to a child, but the artist's economy in the use of color often gives a false impression as to the true coloring of the beasts depicted.

WHAT SHELL IS THAT? *A Guide to the Shell-Bearing Mollusks of Eastern North America.*

By Percy A. Morris. *D. Appleton-Century Co., New York and London.* \$2.25. 3 3/4 x 6; vii + 198; 1939.

An excellently prepared pocket manual which amateur collectors will find most useful. It describes in full and illustrates (photographs in black and white) the typical fresh and salt water shells to be found from Labrador to Cape Hatteras and inland to the Mississippi River.



A NEW PIKA (MAMMALIAN GENUS *OCHOTONA*) FROM SOUTHEASTERN IDAHO WITH NOTES ON NEAR-BY SUBSPECIES. *University of California Publications in Zoology, Vol. 42, No. 6.*

By E. Raymond Hall and H. Lorraine Bowlus. *University of California Press, Berkeley.* 25 cents. 10 1/2 x 6 3/4; 6; 1938 (paper).

FURTHER STUDIES IN REGULATORY DEVELOPMENT OF *TRITURUS TOROSUS*. *University of California Studies in Zoology, Vol. 43, No. 9.*

By Richard M. Eakin. *University of California Press, Berkeley.* 35 cents. 10 1/2 x 6 3/4; 26; 1939 (paper).



BOTANY

GENERAL PLANT PHYSIOLOGY.

By E. C. Barton Wright. Foreword by Sir F. Gowland Hopkins. *P. Blakiston's Son and Co., Philadelphia.* \$4.50. 8 3/8 x 5 1/2; 539; 1938.

PLANT PHYSIOLOGY. *With Reference to the Green Plant. Second Edition.*

By Edwin C. Miller. *McGraw-Hill Book Co., New York and London.* \$7.50. 9 x 6; xxxi + 1201; 1938.

The first text, written from a completely modern viewpoint for first and second year university students, is divided into the following parts: (1) General physiology of the cell (6 chapters), (2) Metabolism (7 chapters), and (3) Growth, reproduction and irritability (4 chapters). There are 44 diagrams in the text, an appendix

on the conception of pH, a general bibliography of 87 titles, and author and subject indexes. The author, formerly lecturer in Botany in the University of London, is now biochemist to the Research Association of British Flour Millers.

The second of these volumes, an excellent text for advanced workers on the physiology of the green plant, has been subjected to the necessary additions and eliminations in order to bring it up to date (first edition appeared in 1931; cf. this Review, Vol. 6, No. 4). The questions that concluded each chapter in the first edition have been omitted in order to conserve space. A commendable feature of the book, which materially adds to its usefulness as a reference book, is the lengthy bibliography which concludes each chapter.



BACTERIAL METABOLISM.

By Marjory Stephenson. Longmans, Green and Co., London, New York and Toronto. \$7.50. 8½ x 5½; xiv + 391; 1939.

The rapid advance in our knowledge of bacterial biochemistry since 1930, when this book first appeared in the *Monographs on Biochemistry*, has made the exhaustive treatment of the whole subject by one author no longer possible. Now, in publishing the book separately as a text for advanced students, the material has been brought up to date. The new edition is as comprehensive as it can be, the articles cited extending from one published in 1838, through Pasteur's "Memoire sur la fermentation alcoolique" of 1860, to various papers published up to the time of writing. Summarizing tables are included in the text, and the appendix gives formulae for various media.

Not only does the author discuss the development of the main trends in bacterial biochemistry thus far, but she also indicates some of the more promising leads for future work.



FUNDAMENTAL PRINCIPLES ON BACTERIOLOGY with Laboratory Exercises.

By A. J. Salle. McGraw-Hill Book Co.,

New York and London. \$4.00. 9 x 6; xiii + 679; 1939.

Stressing chemistry as the basis of modern bacteriology, Salle has presented a well-rounded account of pathogenic and non-pathogenic microorganisms. Planned as an introduction to the subject for students majoring in bacteriology, or as a survey for those whose only course it will be in the field, the book justifies the title. The basic concepts are adequately and clearly, though of necessity briefly, discussed. Although the book runs to nearly seven hundred pages, it is no longer than it needs to be. Indeed, in view of the present trends in bacteriology, the section on filterable viruses might well be longer. The bibliographies, too, might well include more references to the journals, both for the classical articles and for those of the "work-in-progress" type.



THE LEGUMINOUS PLANTS OF WISCONSIN. The Taxonomy, Ecology, and Distribution of the Leguminosae Growing in the State Without Cultivation.

By Norman C. Fassett. Drawings by Richard I. Evans, and a Study of Epidermal Outgrowths by Catherine Mose. University of Wisconsin Press, Madison. \$3.00. 10 x 6½; xiii + 157; 1939.

This scholarly work is the result of an enormous amount of observation and study, both in the field and in the museum. Fassett has presented a very complete list of the Leguminosae of Wisconsin, and has discussed these plants in relation to their taxonomic characteristics and their distribution. The key for identification is very detailed, yet quite simple and understandable. The text is well supplied with photographs of plants and charts showing the geographic distribution of the different species. In addition to the index and glossary, the volume contains a number of carefully prepared drawings, many of which were made from living forms.

The short section by Miss Mose on epidermal growth of the Leguminosae of Wisconsin concludes this body of practical and valuable botanical data.

A FUNDAMENTAL APPROACH TO BACTERIOLOGY.

By Courtland S. Mudge and Floyd R. Smith. J. W. Stacey, Inc., San Francisco. \$2.50. 8½ x 5½; vii + 265; 1939.

This book is the outgrowth of the authors' search "to find a logical method for the teaching of general bacteriology." The experiments were devised in "an attempt to eliminate the minimum in the interest curve" and the text planned "to orient the student from that which has just been accomplished to that which is yet to be done." While not reaching quite the status of a regular textbook it is much more than a manual, although the flexible covers and wired-in pages give it the appearance of such. There are some lengthy excerpts from the Manual of Methods, the two Standard Methods of the American Public Health Association, and from Bergey, "to acquaint the student with such officialdom." A list of 102 important books on various phases of bacteriology is included, also an index.



RECHERCHES SUR LE GNOMONIA ULMEA (SCHW.) THÜM. (*Biologie—Écologie—Cytologie*). Contributions de l'Institut Botanique de l'Université de Montréal. No. 31.

By René Pomerleau. Institut Botanique, Université de Montréal, Montréal. \$1.00. 9 x 6; 139 + 30 plates; 1938 (paper).

Hitherto little has been known of the complete life cycle of *Gnomonia ulmea*, a fungus which attacks the elm, particularly the American species. In this book the author presents the results of an extensive study, showing that it undergoes all its developmental stages on its host (the fungus is strictly obligate to the elm), and fills some of the gaps in the knowledge, especially that concerning sexual determination. The book is illustrated with photographs and schematic drawings to show the different phases in the life cycle of *Gnomonia* and stages of leaf disease, and charts showing the effects of temperature, humidity, etc., on number of lesions on the leaf. The bibliography contains 78 titles.

This work was originally published in the *Naturaliste Canadien* from November 1937 to October 1938.

WILDFOWL FOOD PLANTS. Their Value, Propagation, and Management.

By W. L. McAtee. Collegiate Press, Ames, Iowa. \$1.50. 8 x 6; ix + 141; 1939.

The conservation of our wild ducks, swans, and geese is greatly concerned with their food habits. The results of numerous stomach analyses have made it possible to determine the preference of various wildfowl for certain plants. The method of propagating these food plants, the environmental factors affecting them, and the methods by which man can utilize them to benefit the birds form part of the book. The plants are arranged according to families with a discussion in each group as to their value to the different species of fowl. This book should satisfy the demands of hunters, refuge owners, and game managers for authoritative knowledge on the subject.



NATIVE WOODY PLANTS OF THE UNITED STATES, THEIR EROSION-CONTROL AND WILDLIFE VALUES. U. S. Department of Agriculture. Miscellaneous Publication No. 303.

By William R. Van Dersal. Government Printing Office, Washington. \$1.75. 9 x 5½; ii + 362 + 44 plates + 3 folding charts; 1938.

In the words of the writer

to carry out a program of soil and wildlife conservation vegetation must be utilized intelligently. Where considerable numbers of plants are to be employed, it is essential to know as much as possible about every species of tree, shrub, or herb we propose for planting. . . . "This publication presents an indexed list of woody plants growing in the United States, naming each species as unmistakably as possible, and giving all available data pertinent to its use in erosion control and wildlife conservation.

Two large maps showing climatic provinces and important soil areas in relation to plant growth regions are supplements to this publication.



HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. Lieferung 479. Abt. XI, Chemische, physikalische und physikalisch-chemische Methoden zur Untersuchung des

Bodens und der Pflanze, Teil 4, Heft 8 (Schluss). Ernährung und Stoffwechsel der Pflanzen. Containing the following article: *Bestimmung der Transpiration und Evaporation mit Rücksicht auf die Bedürfnisse der Ökologie*, by Erich Leick.

Urban and Schwarzenberg, Berlin. RM. 14.50; (25 per cent reduction outside of Germany). 10 x 7; 194; 1939 (paper). In this *Lieferung* the different methods and instruments that have been utilized by different workers in the determination of transpiration and evaporation in plants are described and illustrated, together with discussions of their advantages and disadvantages. Climatic factors influencing air and water economy of plants receive consideration. The bibliography covers 7 closely printed pages. The number also contains the complete index for Abt. XI, Part 4 of this handbook, and the table of contents of Abt. XI, Part 4.



POISONOUS PLANTS OF THE UNITED STATES.

By Walter C. Muenscher. *The Macmillan Co., New York.* \$3.50. 8½ x 5½; xvii + 266; 1939.

The first part of this book is a general and brief consideration of poisonous plants, their nature and conditions under which they cause poisoning. The second and more extensive part consists of a detailed treatment of various plants by families. Here each plant is individually described, its distribution and habitat given and its conditions of poisoning discussed. The text is lavishly illustrated with clear black and white drawings and there is a long and complete bibliography and index.



COMMON EDIBLE AND POISONOUS MUSHROOMS OF SOUTHEASTERN MICHIGAN. Bulletin No. 14.

By Alexander H. Smith. *Cranbrook Institute of Science, Bloomfield Hills, Mich.* 50 cents (paper); \$1.00 (cloth). 9 x 6; 71 + 16 plates; 1938.

There is no rule-of-the-hand method of distinguishing poisonous from nonpoisonous mushrooms. Hence this small book,

teaching how to identify edible species and when and where to find them, is a boon to mushroom enthusiasts. Even the best of us aren't infallible apparently, for directly following a list of recipes prepared by his wife, the author has inserted a short section on what to do for mushroom poisoning. An index, glossary and numerous photographs should make this book suitable for use in the field by the amateur collector.



INDEX TO NORTH AMERICAN FERNS. Constituting a Catalogue of the Ferns and Fern Allies of North America North of Mexico, Including All Known Forms, Varieties and Hybrids.

Compiled and Edited by Maurice Broun. Foreword by Charles A. Weatherby. Available from the author, Hawk Mountain Sanctuary, Route 1, Orwigsburg, Penna. \$2.50. 7½ x 5½; 217; 1938.

This authoritative check-list giving the numerous forms, varieties and hybrids of North American ferns with references to texts wherein they are published and described, and including ecologic and geographic data for each species, is destined to become the outstanding guide for students of ferns in the United States and Canada. In taxonomy, the author follows Christensen as much as possible. Included in the volume is a tabular arrangement of the ferns and fern allies listed in the book, a list of authorities cited and an index (37 pages) to scientific names, with synonyms in italics.



AN INTRODUCTION TO BOTANY, With Special Reference to the Structure of the Flowering Plants.

By J. H. Priestley and Lorna I. Scott. Illustrated by Marjorie E. Malins and Lorna I. Scott. Longmans, Green and Co., New York, London and Toronto. \$6.00. 8½ x 5½; x + 615; 1938.

This excellent text for advanced work in plant physiology (green plants only) has undergone the necessary revision and additions in order to bring it up to date (first edition appeared in 1931). The

questions that concluded each chapter in the first edition have been omitted in order to conserve space. The lengthy bibliographies following each section and the detailed author and subject indexes help to make this a useful laboratory guide.



THE FUNGI OF MANITOBA AND SASKATCHEWAN.

By G. R. Bisby, with the Collaboration of A. H. R. Buller, John Dearness, W. P. Fraser, and R. C. Russell. Preface by H. T. Güssow. National Research Council, Ottawa, Canada. \$3.50. 10 x 6½; 189 + 13 plates + 1 folding map; 1938.

This list is not to be confused with *The Fungi of Manitoba* published in 1929 by three of the present authors. This is an entirely new check-list and includes the two provinces of Manitoba and Saskatchewan. There is an index which lists the fungi under their hosts in addition to the regular taxonomically arranged list. Locality records, dates, and hosts are included after the name of each species.



HUMUS. *Origin, Chemical Composition, and Importance in Nature. Second Edition Revised.*

By Selman A. Waksman. Williams & Wilkins Co., Baltimore. \$6.50. 9 x 6; xiv + 526; 1938.

This edition is essentially the same as the earlier volume (cf. Q. R. B., Vol. 11, No. 3) except that the eighth chapter (Humus formation in composts of stable manures and of plant residues; green manures) has been considerably enlarged, and a new chapter, XVIII: Humus and soil conservation, has been added. Wherever necessary the text of the earlier edition has been revised, and, so far as possible, results of recent studies have been added.



PLANT CHEMICULTURE. *A Guide to Experiments in Growing Plants Without Soil. Third Edition, Revised and Enlarged.*

By C. D. Dawson and M. V. Dorn. Dawson and Dorn, 4613 West Washington Blvd., Los Angeles, Calif. \$1.00. 8½ x 5½; 130; 1939 (paper).

This edition (cf. mention of second edition in Q. R. B.: 13, p. 471) has been somewhat enlarged by the inclusion of new textual material and some new photographs.



SILVA FENNICA 46. *Metsänhoitajien Jaskokurssit. [Der Fortbildungskursus für Forstmeister 1937. III.]*

Society of Forestry in Suomi, Helsinki. 9½ x 6½; [4] + 244; 1938 (paper).

ACTA FORESTALIA FENNICA 43. *Suomen Metsätieteilijien Seura—Finska Forstsamfundet.*

Society of Forestry in Suomi, Helsinki. 9½ x 6½; 356 + 20 plates; 1938 (paper).



MORPHOLOGY

OH, DOCTOR! MY FEET!

By Dudley J. Morton. D. Appleton-Century Co., New York and London. \$1.50. 7½ x 5; ix + [7] + 116 + 7 plates; 1939.

The underlying theme throughout this work is that our lack of knowledge concerning the structure as related to the functional activity of the foot has been responsible for the lack of attention paid to foot troubles by most of our general practitioners. As a result, foot ills have all been referred to the shoe specialist, with the consequence that the unenlightened sufferer soon finds himself with a closet full of expensive shoes, and feet that are in as bad a condition as (if, indeed, not worse than) they were in the beginning.

Dr. Morton stresses the use of the X-ray in determining the underlying causes of ailing feet, and suggests many scientific modes of approach in effecting a cure, none of which, oddly enough, includes specially built shoes. The general practitioner will find much in this little volume which will be of extreme value to him in meeting the ever-growing line of sufferers from common foot ailments.

LA MÉDECINE MORPHOLOGIQUE.

By A. Thooris. G. Doin and Cie, Paris. 55 francs. 10½ x 7½; iv + 291; 1937 (paper).

Thooris devotes this monograph to a lengthy statement of his philosophical ideas on the study of constitutional somatology and its significance as a foundation for a biological approach to the study of problems of health and disease. He emphasizes the need for a synthetic view of the individual and regards the study of somatology as a means of arriving at this synthesis since the external morphology is related to that of the internal organs and is, besides, the expression of ontogenetic and philogenetic development. In the main, he elaborates the concepts that characterize the classical French school of constitutionalists, and the classification of morphologic types which he adopts and uses as basis for discussion primarily follows that of Sigaud and the more recent modifications of Baron. In treating of the physiological and pathological variations associated with the several body types the author limits himself to advancing a number of hypotheses that are rational extensions of ideas set forth by Claude Bernard and Pavlov. These hypotheses constitute the substance of this book and while they have no factual foundation they result from a long clinical experience and therefore deserve attention.



ANATOMIA DEL NEONATO.

By Francesco Bellelli. Preface by Giunio Salvi. G.U.F. "Mussolini Sezione Editoriale," Naples. 30 lire. 9½ x 7; [6] + 229; 1938 (paper).

The author's premise is that the anatomy of the newborn—birth to one-two days of extra-uterine life—has important characteristics which differentiate it from the infant and, of course, from the foetus. Therefore, in this monograph he summarizes the anatomical traits peculiar to the newborn as observed by himself and others. Briefly but clearly he describes in the usual textbook order the osteology, myology, angiology, and splanchnology of the newborn, and besides, discusses in

some detail the nervous and endocrine systems. Although the author has limited himself mostly to a survey of the observations reported by continental investigators, the descriptions are fairly complete and one finds emphasized many interesting anatomical features that usually receive only passing notice in the textbooks.



LES PROGRÈS RÉCENTS DE L'EMBRYOLOGIE EXPÉRIMENTALE.

By Maurice Caullery. Flammarion Éditeur, Paris. 22 francs. 7½ x 5½; 236; 1939 (paper).

The rapid strides which have been made in experimental embryology, a field about which little is known by the intelligent public, has prompted Caullery to publish this book. It does not pretend to cover the entire field, but presents the more important advances clearly defining all necessary terms.

Considerations of normal development and its study by using colored marks, are followed by studies on fragmentation of eggs and subsequent fertilization of the parts. Embryonic grafts, organization, and induction are discussed at some length. Very little treatment is given to mammalian forms, the material being largely confined to echinoderms, insects, amphibia, fish, and birds. Frequent drawings illustrate experimental techniques and results obtained.



TEXTBOOK OF NEURO-ANATOMY AND THE SENSE ORGANS.

By O. Larsell. D. Appleton-Century Co., New York and London. \$6.00. 9½ x 6½; xii + 343; 1939.

A text for first year medical students—the outgrowth of the author's experience in teaching neuro-anatomy. The general treatment has been by functional systems, considerable emphasis being placed on functional aspects of the various divisions of the nervous system. The entire presentation is "to aid the student to think as early as possible in terms of functional anatomy." Brief descriptions of lesions

in various parts of the nervous system are included at the end of some chapters. The volume is profusely illustrated, bibliographies conclude the chapters and there is an adequate index.



ELEMENTARY ANATOMY AND PHYSIOLOGY.

By James Whillis. Foreword by T. B. Johnston. Lea and Febiger, Philadelphia.

\$3.50. 9½ x 6½; ix + 342; 1939.

This text has been written for elementary students in order that

the combination of Anatomy with some simple Physiology will make the study of the structure of the body more interesting and profitable to the student during his first year of Medicine. The physiological matter included is not intended to trespass in any way on the function of the existing elementary text-books of Physiology, but is limited to the essentials of function.

The illustrations (87) are of semi-diagrammatic type and the index is adequate. The author is at present University Reader in Anatomy, Guy's Hospital Medical School.



THE FETAL PIG. *An Introduction to Mammalian Anatomy.*

By Hazel E. Field. Stanford University Press, Stanford University, Calif. Oxford University Press, London. 75 cents. 8½ x 5½; ix + 53; 1939 (paper).

An excellent introduction to mammalian anatomy for those students whose acquaintance with the dissecting room will terminate with the final examination in the introductory course. The fetal pig is selected for its similarity in structure to the human body and ease in dissection. Fetal pigs may easily be procured at little or no cost from slaughterhouses. There is a brief general bibliography for student reference. Glossary and index are combined.



SCHAFER'S ESSENTIALS OF HISTOLOGY. *Descriptive and Practical for the Use of Students.* Fourth Edition.

Edited by H. M. Carleton. Lea and Febiger, Philadelphia. \$5.00. 8½ x 5½; xii + 618; 1938.

This book first made its appearance 53 years ago with Sir Edward Sharpey-Schafer as its author. The present edition still retains the general character of the earlier editions although *The Lessons*, the term used to denote the sections, have been revised and some of the older illustrations replaced by photographs. In an appendix is given in detail methods for preparing histological material. The volume contains many (over 650) excellent illustrations and a useful index.



PHYSIOLOGY AND PATHOLOGY

PHYSIOLOGIE DES ANIMAUX MARINS.

By Paul Portier. Flammarion, Éditeur, Paris. 20 francs. 7½ x 5½; 253; 1938 (paper).

This is a small book but between its pages is packed a tremendous quantity of information. The words "animaux marins" are construed very broadly so as to include not only the aquatic birds but even the mythical sea serpent.

The nutrition and respiration of marine animals is thoroughly covered. Also there are chapters on such diverse matters as both the natural and artificial culture of pearls, the effect of changes in salinity and pressure on organisms (there is a great deal about fresh-water forms of life covered under this heading), the methods of obtaining material from great depths, the use of the bathysphere, the use of helium to prevent divers from being overcome by "the bends," protective coloration and mimicry, the operation of the chromatophores, etc., and the evolution of living matter. There is no empiric evidence of the creation of life; according to this author living matter, like Topsy, "just grewed."

The author draws a fine distinction between poisonous and venomous—it seems that a poisonous animal is one like a snake that is actively poisonous, but a venomous animal is one like certain mollusks whose fluids contain so much iodine, bromine, or copper that they passively poison any predator who eats them. Among the actively poisonous animals are the *Cnidaria* that are provided with nematocysts, but there are many forms of

animals not naturally provided with these weapons that obtain them from the original owners. Some crabs detach actinians and plant them on their own carapaces, and some cephalopods are provided with gelatinous cylinders covered with nematocysts which seem to be of coelenterate origin, but how the cephalopods obtain possession of them is not clear. The chapter dealing with locomotion is perhaps the most readily comprehended, since this function is so easily observed. The various forms of locomotion are described and compared, from the ciliary action of the lower plankton to the wings of the penguin which are so modified for swimming that these birds can no longer fly.

This otherwise highly meritorious book has no index. This is unfortunate, for a detailed compendium such as this work needs one. The bibliography contains 87 entries, but it is clear that the author must have consulted many more sources than these in fitting himself for the preparation of such a book.



IMMUNITY. *Principles and Application in Medicine and Public Health. Fifth Edition of "Resistance to Infectious Diseases."*

By Hans Zinsser, John F. Enders and LeRoy D. Fothergill. The Macmillan Co., New York. \$6.50. 9½ x 6½; ix + 801; 1939.

The story of the extraordinarily rapid growth of the science of immunology is told in the successive changes which this work has undergone. The present volume is the fifth edition of the work first published in 1914 under the title "Infection and Resistance." The first three editions appeared under the same title, although each was revised and reset. In 1931 the fourth edition appeared, called "Resistance to Infectious Diseases." The latest volume, published this year, more than any of its predecessors marks the change "from the trial and error method of pure biology" to "the application of methods of physics and physical chemistry" in immunology. An evolution has also occurred in the circle of readers. A quarter of a century ago, although the medical student was interested, the prac-

ticing physician did not yet consider the principles of immunology to be of much actual concern to him. Today the clinician has taken these principles out of the laboratory, and their applications are some of his most effective tools.

In the first half of the 1939 edition Zinsser and his collaborators present a synthesis of what is known "of the biological phenomena of infection and recovery in the animal body." The latter part considers the application of the principles evolved in the earlier section "to diagnosis, treatment, and prophylaxis, and their usefulness in the control of epidemics." Specific diseases are considered in their relation to the principles of immunity, including syphilis and tuberculosis, whooping cough, and protozoan infections, as well as diphtheria, scarlet fever and other hemolytic streptococcal infections.

The senior author holds a unique position of authority in the field of immunology, and his treatment of the subject includes consideration of the most recent developments.



PHYSIOPATHOLOGIE DE LA VIEILLESSE et Introduction à l'Étude des Maladies des Vieillards.

By P. Bastai and G.-C. Dogliotti. Masson et Cie, Paris. 50 francs. 9½ x 6½; 235; 1938 (paper).

Senility according to the authors' definition, is the period of life in which there is an organic and functional involution characterized by a predominance of the regressive and destructive processes over the constructive phenomena. They take the position that senility is a condition or disease *sui generis* that exists independently of other pathological states and they emphasize the distinction between the physiological and pathological changes that are peculiar to senescence from the diseases, such as arteriosclerosis, which very often accompany old age. In the first section of the monograph, they present the summary of a mass of observations, their own and of others, regarding the anatomical and functional conditions observed in the various organs and organ-systems of the aged. They conclude after

a thorough survey that the characteristics of senility result practically always from alterations in the capillary system. The evidence to support such a view while not definitive appears adequate, and, as the authors note, this conclusion is not contradicted by the views of other students of the subject. In the second part of the book the authors discuss the manifestations of acute and chronic diseases in the aged and the interpretation of the courses of these diseases in terms of their conclusion. The authors have approached their study in a true empirical fashion and although many hypotheses involving elegant theorization have been advanced about senility, the conclusion reached by the authors, limited as it is in philosophical scope, is worthy of serious consideration on its merits alone quite aside from the eminence of those who have conceived it.



ALCOHOL IN MODERATION AND EXCESS.
A Study of the Effects of the Use of Alcohol on the Human System.

By J. A. Waddell and H. B. Haag.
William Byrd Press, Richmond, Va.
\$1.00. 9 x 6½; 184; 1938.

This comprehensive treatise on the relation of alcohol to the physiological and psychological activities of the body was prepared at the request of the Virginia State Legislature. After it was carefully completed by the committee of eight medical men from the medical faculty of the University of Virginia, and the Medical College of Virginia, it was referred to the Senate to be printed as a Senate Document, but was rejected as a result of strong opposition by a dry block in the legislative body. The opposition came, in all probability, because the report did not give all the orthodox answers to the questions concerning the use of alcohol on the body.

The general conclusion is reached that alcohol in moderation produces very few of the effects it is generally accused of producing; but, on the other hand, its use in excess is responsible for all the effects it is accused of, and more besides. Stress is placed on the effect of excessive alcoholism in habit forming, degrading

of social and moral standards, and in the deterioration of body and mind. The study is based on a thoroughly scientific approach rather than a moral one, and is presented in a scholarly and authoritative manner.



L'OPERA DEL COMITATO ROMANO PER L'ASSISTENZA ANTIMALARICA DAL 1921 AL 1935.

Comitato Romano per l'Assistenza Antimalarica. Tipografico Luigi Proja, Rome.
10½ x 7; 95 + [5] + 32 plates + 2 folding maps; 1938 (paper).

This is the official account of one aspect of the anti-malaria campaign conducted from 1921 to 1935 in the rural section of the Roman region of Italy. The whole program as developed has consisted of health propaganda utilizing movies, literature and speakers, reclamation of the land by irrigation and similar means, and finally, the introduction of mobile dispensaries to distribute quinine for prophylaxis and for treatment, as well as to make epidemiological studies. The report is concerned primarily with the third type of activity. It describes the organization of the health units, the means adopted to get the cooperation of local physicians, of the farm-workers and of the landowners, the quinine compounds used and the results of laboratory examination of blood plasma. In addition, it presents statistics on the number of persons treated each year and the number of new and old cases. The results have been gratifying. Annually there has been a perceptible reduction in the number of cases of malaria and moreover the benefits of quinine as a prophylactic have been definitely realized and understood by the people. Whether the decline of malaria will continue once the intensive and, of course, costly campaign is abandoned can only be learned in the future. In the meantime, the reclamation of the land has progressed rapidly enough and as everyone knows, thanks to efficient government news service, thriving communities stand today where there were formerly only marshes. So, temporarily at least, the campaign may be considered successful.

THE BIOLOGY OF THE CELL SURFACE.

By Ernest E. Just. P. Blakiston's Son and Co., Philadelphia. \$5.50. 9 x 6; xi + 392; 1939.

If one were to designate the biological category into which this book most naturally falls, doubtlessly it would be the field of general physiology; but certainly the book is not a conventional account of the physiology of protoplasm, or even of a part of this field. It is a monograph on *ectoplasm*. "In all cells of . . . animals, the existence of the ectoplasm can be demonstrated"—so the author states in the opening of his summary. The ectoplasm is the superficial region of the protoplasmic ground-substance, and Just believes that it differs from the endoplasm in its special properties. The book deals with phenomena of conduction, contraction, respiration, the intake and output of water—these being general properties of all animal cells—but also, and more specifically, it discusses the mechanisms of fertilization, parthenogenesis, cell-division, and development in animal eggs. "The reactions underlying both differentiation and heredity" are "shown to be under the domination of cytoplasmic reactions resulting from the interplay of both ectoplasm and nucleus with the cytoplasm." The philosophical implications of Just's theory are discussed at some length.



MEDICAL AND SANITARY REPORTS FROM BRITISH COLONIES, PROTECTORATES AND DEPENDENCIES FOR THE YEAR 1936. *Tropical Diseases Bulletin*, Vol. 35, Supplement, November, 1938.

Summarized by P. Granville Edge. Bureau of Hygiene and Tropical Diseases, London. 7s. 6d. 9½ x 6; 296; 1938 (paper).

Anyone who has had occasion to turn to medical reports of colonial officers will appreciate this, the eighth annual summary of the reports from the British colonies. Although not every report is complete, a wealth of information about vital statistics, incidence and distribution of various diseases, public-health administration, etc., is given. Since the majority of the colonies are tropical or

semi-tropical, the so-called tropical diseases predominate. As a picture of the British colonial medical service in action, or as an index to the various reports, the summary is invaluable.

Especially interesting is the 16-page article entitled, "The incidence and distribution of human trypanosomiasis in British Tropical Africa." The author has brought together, from all of the reports, the data on human trypanosomiasis, discussing it under the headings, incidence and geographical distribution, preventive measures, treatment, and research.



PROBLEMS OF AGEING. *Biological and Medical Aspects. A Publication of the Josiah Macy, Jr. Foundation.*

Edited by E. V. Cowdry. Williams & Wilkins Co., Baltimore. \$10.00. 9 x 6; xxx + 758; 1939.

As the proportion of the aged in the population increases, gerontology will eventually become a far more intensive enquiry. A worthy contribution in this direction is made by this symposium which contains articles by 25 noted biological and medical scientists. The main purpose of the publication is to focus attention on the several theoretical and practical aspects of the processes of ageing. The authors in general have given a thorough review and summary of the existing knowledge in the fields they treat. The first four articles deal with a discussion of ageing phenomena in plants, protozoa, invertebrates and vertebrates. In two articles that follow, anthropological and demographic considerations are presented. Then there are articles concerning the pathology and physiology of the various organs and organ-systems in relation to age and the psychological and psychiatric aspects of the problem. The viewpoints developed and the conclusions reached point to the fact that greater knowledge of the biology and biochemistry of ageing phenomena is needed and that psychological and social factors are involved to a greater extent than has heretofore been realized. Notwithstanding the many questions dis-

cussed here, it is only too obvious that not all the problems have been noted. It is hoped that this book will serve to stimulate further study.



A MEDICAL SURVEY OF THE REPUBLIC OF GUATEMALA.

By George C. Shattuck, with the collaboration of Joseph C. Bequaert, Margaret M. Hilferty, Jack H. Sandground and Samuel D. Clark. Carnegie Institution of Washington, Washington, D. C. \$2.50 (paper); \$3.00 (cloth). 11½ x 9; xi + 253 + 2 folding maps; 1938.

This is a report of a survey, organized by the Department of Tropical Medicine of the Harvard School of Public Health and carried out in 1932 under the auspices of the Carnegie Institution of Washington. Margaret M. Hilferty has contributed chapters on the vital statistics of Guatemala and a statistical study of morbidity and mortality at Quirigua from 1919 to 1931; S. D. Clark, one on diseases of the Peten District of Guatemala; Jack H. Sandground, one on helminthic infections of man; and Joseph C. Bequaert, two chapters, one on the Arthropoda of medical importance in Guatemala and the other on the distribution of *Phlebotomus* in Central and South America. The major part of the work is the contribution of George C. Shattuck who outlines the history, probable origin and incidence of the infectious diseases of Guatemala and gives a more detailed study of malaria, chancro ulcer, syphilis and yaws, anemia, goitre, myxoedema and cretinism, circulatory and renal disorders, etc.

Nearly all the separate chapters include a list of references. The book is indexed and is illustrated with 5 graphs and three maps.



LANDMARKS IN MEDICINE. *Laird Lectures of the New York Academy of Medicine.* New York Academy of Medicine.

Introduction by James A. Miller. D. Appleton Century Co., New York and London.

\$2.00. 7½ x 5½; viii + 347; 1939.

The New York Academy of Medicine annually invites the public to attend a

series of lectures. This book, incorporating the discourses of one such series, may further a growing understanding between the doctor and those whom he serves.

Alfred E. Cohn presents an interesting discussion of medical research which, he says, must be a serious undertaking with ample equipment and just rewards, but subject to free criticism. The reader is given an insight into the medico-legal aspect of crime detection by Harrison Martland. He discusses critically the merits of the medical examiner's system as opposed to the coroner's office. "The Search for Longevity," a subject of universal interest, is treated by Raymond Pearl. Both hereditary and environmental factors are considered, and particularly the influence of alcohol, tobacco, and work. One of the pioneers in the field of X-ray, Dr. Lewis Gregory Cole, tells in a personal manner about the difficulties which had to be overcome before the X-ray assumed its present position of high diagnostic value.



IODINE AND THE INCIDENCE OF GOITER.

By J. F. McClendon. University of Minnesota Press, Minneapolis; Oxford University Press, London. \$5.00. 11 x 8½; vi + [4] + 126; 1939.

This scholarly contribution is the result of many years' work in the collecting and classifying of data concerning the geographical distribution of iodine and its relation to the incidence of goiter. The work has occupied the interest of the author for nearly 30 years, and has taken him to many corners of the earth. McClendon has made no attempt to include such topics as the anatomy of the thyroid gland, or the classification of goiter, or any of the phases of the medical treatment of goiter; but has confined his discussions to the geographical distribution of iodine, its place in the field of nutrition, and its relation to the incidence of goiter. The text contains numerous tables and figures which are effective in demonstrating the undeniable relationship between iodine insufficiency and thyroid abnormalities.

A chapter on iodine determination, an author index, and a subject index conclude the book.

HEALTH AT FIFTY.

Edited by William H. Robey. Harvard University Press, Cambridge. \$3.00. 8 x 5½; x + 299; 1939.

The aim of the lectures which make up this book . . . is to clarify, explain, and interpret the recent developments in various departments of medicine and medical research, to warn of unsuspected dangers, and to stress the necessity of seeking sources of skilled advice rather than temporizing, depending on personal interpretation of symptoms, or tampering with drugs, techniques, or cults which have neither efficacy nor scientific basis.

The authors of these twelve essays are from the faculty of Harvard Medical School. They present their topics in non-technical language, easily understandable to the layman. The volume largely confines itself to later life disorders such as cardiovascular diseases, cancer, arthritis, and the menopause. Among topics not defined by age limits there are sensible discussions on weight abnormalities, care of the eyes and mental health. A lecture entitled "The Family Medicine Cabinet" will be a revelation to homemakers.



LE CANCER.

By Gustave Roussy. Librairie Armand Colin, Paris. 15 francs (paper); 17.50 francs (cloth). 6½ x 4½; 224; 1939.

Although this little book has been written for the layman, it contains so much information and is so up-to-date that it can be of interest even to the medical reader. Roussy's idea was to give to the public some notion of the tremendous amount of cancer research which has been done in recent years, if only so that they would come to see that physicians are not so entirely hopeless or so entirely ignorant about the disease as they once were. Once the layman comes to realize this he will perhaps be less likely, when he finds himself afflicted with cancer, to throw up his hands in despair or to go to a quack.

In the final chapter Roussy reviews briefly what the governments of the several civilized countries of the world are doing in the way of combatting cancer.



VACCINATION CONTRE LA SÉNESCENCE PRÉCOCE.

By C. Picado. Preface by Professor Caul-

lery. Librairie E. Le François, Paris. 22 francs. 8½ x 5½; 240; 1937 (paper).

Searchers for the fountain of eternal youth never dreamed of its emanating from anything as small as a hypodermic syringe. Old age is thought of by the author as a disease, and as such we shall be able to immunize against it if we can find and properly apply a vaccine. Accordingly, after a brief treatment of reproduction and growth, he deals with the causes of senescence and arguments against the possibility of rejuvenation. Hormonal cycles and age differences in the chemistry of the body and blood serum may furnish the key to the problem. Picado discusses these factors and then presents results of experimental life prolongation in lower forms. The treatise ends with considerations of the short and long lived races of animals. An extensive bibliography is included.



FUNDAMENTALS OF PHYSICAL EXAMINATION.

By George G. Deaver. W. B. Saunders Co., Philadelphia and London. \$2.75. 7½ x 5½; 299; 1939.

The various techniques used in physical examination together with pathological findings in the various regions of the body are briefly described in this book which is designed for the physical educator rather than the physician. The information presented is, on the whole, highly superficial, with the inclusion of useless detailed medical verbiage. The presentation is academic, each chapter being followed by Lessons to be Written, Laboratory Work and Self-Tests. The bulk of the subject matter seems to lie far outside the functions of the physical educator who can hardly be expected to acquire more than a dangerous mite of knowledge, or a false confidence in his diagnostic ability, from even complete mastery of this book. A glossary of medical terms and an index are included.

LE CORPS JAUNE. *Étude biologique, clinique et thérapeutique.*

By H. Simonnet and M. Robey. Preface by L. Portes. Masson et Cie, Paris. 50 francs. 9½ x 6½; 171; 1939 (paper).

This book divides into two parts: I. Experimental study, including the formation and structure of the corpus luteum, biochemistry of lutein tissue, and chemistry of the luteinizing hormone, pharmacodynamic action of the corpus luteum extracts and hormones on the genital apparatus, particularly during pregnancy, physiological processes; II. Clinical study, including tests of the functional state of the corpus luteum, its pathology, and therapeutic uses of corpus luteum preparations in the treatment of menstrual disorders, sterility, abortion and menopause. The book is more a synthesis of the literature than a presentation of original work. Lengthy bibliographies end the individual chapters.



NUTRITION: THE NEWER DIAGNOSTIC METHODS. *Proceedings of the Round Table on Nutrition and Public Health. Sixteenth Annual Conference of the Milbank Memorial Fund, March 29-31, 1938.*

Milbank Memorial Fund, New York. \$1.00. 9 x 6; 192; 1938 (paper).

With A. Graeme Mitchell and R. M. Wilder as chairmen, a group of specialists in several branches of the field of nutrition gathered at a round table conference called by the Milbank Memorial Fund in March, 1938. This report includes the papers presented at the meeting and the discussions that ensued. They deal with the use of roentgenology, electrocardiography, dark adaptation and hematologic tests in determining nutritional deficiencies and avitaminosis particularly. The articles are all informative and the lists of recent literature accompanying them are most useful.



THE EFFECT OF DIFFERENT PERCENTAGES OF PROTEIN IN THE DIET OF SIX GENERATIONS OF RATS. *Stanford University Publications. University Series. Biological Sciences, Volume VI, Number 4.*

By James R. Slonaker. Stanford University Press, Stanford University, Calif. Oxford University Press, London. \$1.00 (paper); \$1.75 (cloth). 10½ x 7; 67; 1939.

This study aims to determine the approximate protein percentage in the diet for maintenance of the highest level of physiological performance in rats. Five different protein diets were fed to several groups of rats, and these groups were compared in activity, development, reproduction, and mortality, embodying 49 comparisons in all. No single diet was superior to the others in every one of the processes studied, but in the total series 14.2 percent protein was most efficacious, higher amounts being advantageous during reproduction. The writer suggests that with modifications his findings may be applicable to higher forms, since this percentage approximates certain standards recommended for man.



LE PHOSPHORE DES VÉGÉTAUX. Son rôle dans l'énergétique cellulaire. I. Phosphore Minéral et Glucidique.

By E. Michel-Durand. Presses Universitaires de France, Paris. 30 francs. 10 x 6½; viii + 99; 1939 (paper).

The author divides the phosphorus found in plants as follows: phosphates and pyrophosphates (mineral P), phosphoglucide esters (glucide P), phosphatides (lipid P) and nucleoproteides and derivatives, the phosphoproteids (protid P), most of which are also found in animals. This book treats the first two; the others will be dealt with in later volumes. The three chapters concern mineral phosphorus, glucide phosphorus and phytine, giving for each the amount and distribution in the parts of the plant, methods of extraction and preparation, properties and biological rôle. There is a bibliography but no index other than a detailed table of contents.



ZUR NORMALEN UND PATHOLOGISCHEN ANATOMIE DES GREISENALTERS.

By Ludwig Aschoff. Urban and Schwarzenberg, Berlin and Vienna. RM. 2.50; (25 percent less outside of Germany). 9 x 6; 116; 1938 (paper).

This is a collection of papers originally published in the weekly *Medizinische Klinik*. The author, himself one of the leading German pathologists, gives an

admirable short and precise review on the physiological changes in senility. He describes one after the other, the most important changes in all the different organ systems—mostly from the pathological-anatomical point of view. Statistical methods and life table experiences are scarcely mentioned. However, the statistics of causes of death in old age (over 65 years) on the basis of personal experience with 400 cases, post-mortem examinations in Freiburg, are included.



BIOLOGY FOR PHARMACEUTICAL STUDENTS AND OTHERS.

By S. Mangham and A. R. Hockley.
William Wood and Co., Baltimore. \$6.50.

8½ x 5½; vii + 613; 1938.

This book "is designed primarily to meet the requirements in Biology of students preparing for the Preliminary Scientific Examinations of the Pharmaceutical Society of Great Britain." Quite apart from this special feature, the fundamental principles of biology, as well as the more important physiological principles are treated in considerable detail so that the book can well be used in general biology courses. Most of the illustrations (299 figures), nearly all of which have been prepared by the authors, are partly diagrammatic in order to serve the student as a guide to his own observations. There is an adequate index.



FUNDAMENTALS OF EXPERIMENTAL PHARMACOLOGY. Second Edition.

By Torald H. Sollmann and Paul J. Hanzlik. J. W. Stacey, Inc., San Francisco. \$4.25. 9 x 6½; 307; 1939.

This second edition has been completely revised to include new material in line with recent advances in the field of pharmacology. Obsolete matter has been deleted. The text is divided into two parts; chemical pharmacology and experimental pharmacodynamics, each containing practical exercises and tested methods. The material is so arranged that the experimental work can be given as an independent course, or integrated with a course of

systematic lectures. There are several valuable appendices, a bibliography and an index.



PRINCIPLES OF HEALTH EDUCATION. Second Edition.

By C. E. Turner. D. C. Heath and Co., Boston. \$2.00. 7½ x 5½; xvi + 335; 1939.

This is a short but comprehensive textbook dealing with health education, its relation to general education and to public health. It gives a well-planned program of health instruction and is designed for school teachers, school physicians and other persons concerned with health education and health training.



DIETS OF FAMILIES OF EMPLOYED WAGE EARNERS AND CLERICAL WORKERS IN CITIES. U. S. Department of Agriculture. Circular No. 507.

By Hazel K. Stiebeling and Esther F. Phipard. Government Printing Office, Washington. 15 cents. 9½ x 5½; 141; 1939 (paper).

An analysis of the content, cost and nutritive adequacy of diets of wage earners and clerical workers. It is based on dietary records covering one week each, obtained during the period December 1934–February 1937, in 43 industrial centers in 8 major geographical regions of the United States. About 4,000 records were analyzed. The data (presented in 70 tables) are so arranged as to be useful to other workers in this field. There is a bibliography of 68 titles.



LA PONCTION STERNALE. Procédé de Diagnostic Cytologique.

By P. Emile-Weil and Suzanne Perlès. Masson and Cie, Paris. 75 francs. 10 x 6½; 183 + 6 plates; 1938 (paper).

Drs. Emile-Weil and Perlès have here produced an interesting volume, beautifully illustrated with colored plates, showing the diagnostic help that can come from puncturing the sternum and studying

stained smears made from the marrow. The method helps in recognizing submerged leukemias and some of the syndromes in which there is an excessive production of erythrocytes. The book will be of interest to hematologists.



STUDIES ON PROLONGED PREGNANCY IN RATS.

By Finn Bøe. Levin and Munksgaard, Copenhagen. Kr. 10. 10 x 6½; [8] + 146; 1938 (paper).

A strain of highly inbred rats were carefully studied as to the results of delayed parturition. The delay was caused by three different methods: administration of gonadotropic hormones, mechanical stricture of the uterine horns, and hypophysectomy. The investigation shows the effect of this upon the mechanism of birth, the fetus, the placenta, and the endocrine organs. Of particular interest are the rôles of estrone and progesterone.



HANDBOOK OF MICROSCOPIC CHARACTERISTICS OF TISSUES AND ORGANS.

By Karl A. Stiles. (Copies obtainable from the author, Coe College, Cedar Rapids, Iowa.) \$1.50; discounts for quantity orders. 11 x 8½; [6] + 59; 1939 (paper).

This handbook is the expansion of a former outline "Aids to the microscopic identification of tissues and organs." Each topic is presented in condensed form with salient points, in some cases arranged in chart form. The value of the outline would seem to be in its usefulness as a syllabus in connection with textbooks of histology.



PHYSIOLOGY OF MUSCULAR ACTIVITY. Second Edition, Revised.

By Edward C. Schneider. W. B. Saunders Co., Philadelphia and London. \$3.00. 7½ x 5½; 428; 1939.

The first edition of this volume appeared in 1933 and was reviewed in Vol. 9, No. 3 of this journal. For the second edition the text has been revised to conform with

the knowledge of today and some new material and a glossary have been added increasing its size by 28 pages.



THE CHEMISTRY OF NATURAL IMMUNITY.

By William F. Koch. Christopher Publishing House, Boston. \$2.00. 7½ x 5½; 199; 1938.

A presentation of the development of, and the theory behind, the glyoxylide treatment of cancer, coronary occlusion, advanced arteriosclerosis, syphilis, epilepsy, and hay-fever. It is written by the originator of the treatment.



BIOCHEMISTRY

THE STUFF WE'RE MADE OF.

By W. O. Kermack and P. Eggleton. Longmans, Green and Co., New York; Edward Arnold and Co., London. \$3.20. 7½ x 5; viii + 342 + 8 plates; 1938.

This very readable and entertaining book (a book-of-the-month; Scientific Book Club) by two eminent biochemists of the University of Edinburgh interprets for the layman the science of biochemistry, which is defined in the words of the authors as "the meeting place of the animate and inanimate worlds." There are chapters on atomic bricks, molecular architecture, giant molecules, vitamins, enzymes, sex hormones and reproduction, growth, and other such pertinent subjects.

In the chapter entitled "A sense of proportion" the authors endeavor to give the reader a picture of the entire universe. This is done by means of a scale at the bottom of which is the proton and at the top of which is the universe with a weight of 10^{78} protons. Every object in the universe is within 0 and 78 with the exception of the electron which is on the negative side of the scale. Man appears at about 29. Somewhere from 6 to 9, the region called the colloidal range, the complex phenomena of life first appear.



HANDBOOK OF FOOD MANUFACTURE. A Handbook of Practical Food Information,

Containing Factory Tested Commercial Formulae and Descriptions and Analyses of Prepared Foods and Raw Materials.

By F. Fiene and Saul Blumenthal. Chemical Publishing Co., New York. \$6.00. 9 x 6; vi + 603; 1938.

This book is written for the "manufacturer, chemist, plant superintendent, food buyer, and broker, in the baking, beverage, confectionery, condiment, essence, fruit juice, fruit, flavor, ice cream, preserving, spice, and allied food industries. As the title page indicates, a wide field is covered. Some of the material is technical; for example, the sections on chemistry of sugars, baking powders, tests and analyses of edible oils and fats, and action of nitric acid on different oils. On the other hand, there is much that the average individual can comprehend. A great deal of information is given about different kinds of cheese; directions are given for making flavoring extracts, artificial fruit oils and essences, and liqueurs; formulae for pie filling powders, and many kinds of cake, etc., such as the elaborate affairs one sometimes sees on display in the baker's window. The latter part of the volume is devoted to analyses and tests, weights and measures, common and chemical names of various materials, and definitions and standards for food products for use in enforcing the food and drugs act. In short, the volume is a sort of *vade mecum* for the manufacturer of food; but the compiler of cook books and those who write about food for newspapers and women's journals will also find it useful. An adequate index is provided.



EXPOSÉS ANNUELS DE BIOCHIMIE MÉDICALE.

Published under the direction of Michel Polonovski. Première Série by E. Aubel, E. J. Bigwood, P. Boulanger, P. Fleury, Ch.-O. Guillaumin, M. Javillier, M. Machéboeuf, M. Polonovski, Ch. Sannit, R. Wurmser and R. Wolff. Masson and Cie, Paris. 75 francs. 9½ x 6½; 269; 1939 (paper).

This book is made up of a series of excellent articles on biochemical topics of immediate interest to practicing physicians. The articles seem to be up-to-date, and

well worth reading. There are chapters on the production of, and excretion of ammonia, on the deoxydizing reactions of living organisms, on diastases, vitamins, and provitamins, on hormones, and on the transformation of glycogen into lactic acid in muscle. There is a fine article on the cancerogenic substances and another on the metabolism of the body invaded by cancer. There are articles on the serum proteins, on lipids, the metabolism of calcium, and the methods of adsorption of substances.



THE BULLETIN OF MATHEMATICAL BIOPHYSICS. Volume 1, Number 1. Published as a Supplement to *Psychometrika*.

Edited by N. Rashevsky. University of Chicago, Chicago. Subscription price \$2.50 annually. 10 x 6½; 73; 1939.

The *Bulletin*, published as a supplement to *Psychometrika*, is devoted to publications of research in mathematical biophysics, as contributing to the physico-mathematical foundations of biology. This number contains the following papers: Mathematical biophysics of cell respiration. II, by H. D. Landahl; Note on biological periodicities, by Alvin M. Weinberg; The mechanism of cell division, by N. Rashevsky; On the mechanics of viscous bodies and elongation in ellipsoidal cells, by Gale Young; Mathematical biophysics of the cell with reference to the contractility of tissues and amoeboid movements, by N. Rashevsky; Concerning Rashevsky's theory of the *Gestalt*, by A. S. Householder.



LA PRESSION COLLOÏDO-OSMOTIQUE DES LIQUIDES BIOLOGIQUES. Travail des Laboratoires Auguste Lumière.

By Paul Meyer. Imprimerie Léon Sézanne, Lyon. 30 francs. 9½ x 6½; ix + 218; 1939 (paper).

Except for the last chapter this book is an objective presentation of the findings of many workers—the bibliography runs to 610 titles—on the physical chemistry and biological rôle of colloidal osmotic pressure of the body liquids in health and

disease. In the last chapter the author expresses his opinions gained from ten years' experimental work of his own. He disagrees with the concept advanced by Starling, namely that colloidal osmotic pressure is the regulator of tissue metabolism of the liquid, but returns to the classical theory that it is the expression of processes that occur in the tissues. There is no index, but a detailed table of contents.



SEX

HARMONY IN MARRIAGE.

By Leland F. Wood, with the help of Robert L. Dickinson. Round Table Press, New York. \$1.00. 7 x 4 $\frac{3}{4}$; vi + 122; 1939.

In this little book, Mr. Wood has given lively verbal expression to one of the deepest set elements of his philosophy of life; namely, that a word in time often forestalls matrimonial shipwreck. This is surely one of the most worthy causes to which any man could dedicate his life, and the author is to be commended for the sincere and enthusiastic presentation of his experiences, his convictions, and his most wise council.

The obvious paradox associated with the dissemination of such knowledge as this volume has to offer is that it will never reach those unfortunate souls who need it most. Those folks who never read books, and who do not profit by their association with those who do, will be the ones who need the elementary training in matrimonial harmony contained in these pages. But how will they get this training? The book contains very little that will add to the store of common sense of folks who are readers, and who are wide-awake to the happenings in the world about them. It is hard to believe that in the latter group, one would find a person whose naivety would prompt him, upon facing some serious trouble, to take down *Harmony in Marriage* from his library shelf, and turn to page 113 and offer up the prayer which is so neatly written out there for that specific purpose.

OUR SEX LIFE. *A Guide and Counsellor for Everyone.*

By Fritz Kahn. Translated from the German by George Rosen. Alfred A. Knopf, New York. \$6.00. 9 $\frac{1}{2}$ x 6 $\frac{3}{8}$; xxxviii + 459 + 29 plates; 1939.

In 735 numbered paragraphs the author gives information and advice on sex anatomy and function, sex hygiene, and sex behavior, beginning with the cell and ending with the solution of the sex problem (paragraph 725 tells us that the sex problem is unsolved, but not incapable of solution). Although the author at times waxes a little too poetic, the book contains more sense and fundamental information than many of the *vade mecum*s of the sex life now on the market. It is interesting, however, to note paragraph 266 which is opposed to the newer theories: "The capability of the woman to conceive varies during the month, . . . but there are no 'safe' days. The sperm cell can live for days, even for weeks, within the sex apparatus and await the arrival of a new egg there."

This English translation, already well-known in the original under the title *Unser Geschlechtsleben*, should be welcome.

GESCHLECHT UND GESCHLECHTSBESTIMMUNG IM TIER-UND PFLANZENREICH. *Sammlung Götschen, Band 1127.*

By Max Hartmann. Walter de Gruyter and Co., Berlin. RM. 1.62. 6 $\frac{1}{2}$ x 4 $\frac{1}{2}$; 110; 1939.

This small volume of the *Götschen* series was designed as an introductory text, for the interested layman as well as for the student, of sex organs and sex determination in plants and animals. Naturally, in a book limited to this size, not all aspects of the subject are included, and for the most part discussion of the secondary sex characters has been omitted. It is, however, accurate and authoritative and should serve the purpose for which it was intended. It is illustrated, and a glossary of terms and an index have been provided.

BIOMETRY

RESEARCH AND STATISTICAL METHODOLOGY.
Books and Reviews 1933-1938.

Edited by Oscar K. Buros. Rutgers University Press, New Brunswick, N. J.

\$1.25. $9\frac{1}{2} \times 6\frac{1}{2}$; vi + 100; 1938.

Some men *write* books, and some write book-reviews. Then, some men *collect* books, while some collect bibliographies and reviews. Rare, however, is the man who *publishes* his collection of book-reviews. The editor of the above volume has done just that. Agreeing, with Harold Hotelling, that a revolution has taken place in the field of statistics, and believing that the modern developments should be made more accessible in order that the use of older, less efficient, and incorrect methods of statistical analysis may not be unduly prolonged, Buros has published evaluative excerpts from selected critical reviews of books on statistical and research methodology. The present catalogue pertains to works published during the 1933-through-1938 interval. Similar collections may be published annually hereafter.



LEHRBUCH DER MATHEMATIK zum Selbstunterricht und für Studierende der Naturwissenschaften und der Technik. Eine Einführung in die Differential- und Integralrechnung und in die analytische Geometrie. Siebente Auflage.

By Georg Scheffers. Walter de Gruyter and Co., Berlin. RM. 15. $9\frac{1}{8} \times 6\frac{1}{8}$; viii + 743; 1938.

This is the seventh edition of a well-known textbook. The author is himself an engineer and prepared the book especially for self-instruction and for the use of students in natural and technical sciences. Numerous examples in analytic geometry, and differential and integral calculus are given from a more practical point of view. The book has found many readers among students and teachers in Germany because it gives not only formulas suitable for the professional mathematician but also a relatively broad treatment in all the chapters. There is a very good chapter on the law of organic growth and exponential functions. As is usual in

general text-books of this kind, the theory of probability is hardly touched upon.



STATISTICAL TECHNIQUE IN AGRICULTURAL RESEARCH. *A Simple Exposition of Practice and Procedure in Biometry.*

By D. D. Paterson. McGraw-Hill Book Co., New York and London. \$3.00. 9×6 ; ix + 263; 1939.

Here is more evidence to indicate that the biologist of the future, no matter in what field his interests may lie, will be plagued by mathematical techniques. For accurate and meaningful interpretations of agricultural experimentation a statistical analysis is indispensable. The author demonstrates the various methods applicable to field experimentation. The statistical techniques employed are mostly those used when only a small number of variables are taken into consideration. An attempt has been made to render the presentation as reasonable as possible for the nonmathematically inclined research worker.



SIMPLIFIED STATISTICS.

By Leonard J. Holman. Sir Isaac Pitman and Sons, London. 3s. 6d. net. $7\frac{1}{2} \times 4\frac{1}{4}$; xii + 142; 1938.

This gem of a book introduces the concepts of statistics almost without recourse to algebra. It is not an exposition of statistical theory, nor yet of statistical practice; it does not explain the underlying logic of statistics, nor does it provide ready-made the formulae with which the computer may work miracles. On the contrary, the aim is simply to set forth those basic statistical concepts which are common to natural science, commerce, and everyday life, and which should be a part of the general education of everyone. The book fulfills this aim in a most attractive manner.



PRINCIPLES OF THE THEORY OF PROBABILITY. *International Encyclopedia of Unified Science. Volume 1, Number 6.*

By *Ernest Nagel*. *University of Chicago Press, Chicago*. \$1.00. 9½ x 6½; vii + 80; 1939 (paper).

In this number Nagel discusses some of the logical bases of the calculus of probability. A brief historical survey introduces the subject and it is followed by an enunciation of the fundamental elementary theorems. The remainder of the monograph is devoted to critical review of the philosophy underlying the definition of probability and the frequency and non-frequency interpretations of probability calculus. For those not acquainted with the language and viewpoints of the student of logic, symbolic logic particularly, there are many statements which may appear rather unusual and difficult to understand.



COLLECTION AND PRESENTATION OF STATISTICAL DATA IN PSYCHOLOGY AND EDUCATION.

By *Martin F. Fritz*. *Prentice-Hall, Inc., New York*. 65 cents. 8 x 5½; vi + 58; 1939 (paper).

Written for the beginner, this small manual gives in a very simplified form some of the procedures in the collection, tabulation and graphic presentation of statistical materials. Tables and graphs illustrate the work, and questions for discussion, a list of useful books on statistics, and an index have been added.



PSYCHOLOGY AND BEHAVIOR

THE MECHANISM OF THOUGHT, IMAGERY, AND HALLUCINATION.

By *Joshua Rosett*. *Columbia University Press, Morningside Heights, N. Y.* \$3.00. 10 x 7; x + 289; 1939.

This is a highly technical book. It is one of the results of the natural reaction of human intelligence to the chaos to which the metaphysicians of the 19th century had reduced psychology.

The premise on which the author builds his thesis is the Law of Evolution and Dissolution as defined by Herbert Spencer. The meaning of this law can best be illustrated by a quotation from the introduc-

tion: "Reason and judgment are recently acquired nerve functions, in the course of an individual's lifetime. In poisoning by alcohol, these functions are the first to succumb and they are the last to appear during recovery from the action of poison. On the other hand, respiration is phylogenetically a very old function; it is the last to be affected by the action of the poison and the first to recover."

The savants of past generations would have explained this result without recourse to Spencer's law. They would have attributed the differential disappearance and reappearance of reason and respiration, not to differences in phylogenetic age, but to differences in fundamental nature. Reason, they would have pointed out, is an activity of the mind and respiration one of the body, and to them such a statement as that embodied in the above quotation would have been considered evidence of loose thinking. But in reality it is not so, for Rossett considers reason and judgment to be just as physiological as respiration. The word "mind" does not occur in his book except in the historical introduction. In this he breaks completely with the classical tradition of William James and his satellites.

The book is largely a discussion of empirical evidence to show that not only in alcoholic poisoning but in all other forms of suspended cerebration, such as encephalitis or other diseases, physical injury to the brain, epileptic seizure, or even normal sleep, the phylogenetically younger activities are always the first to be lost and the last to be recovered. The chapter on sleep is the longest and perhaps the most informative in the book. The mental activities suspended during sleep are classified under the headings "Thought," "Imagery," and "Hallucination." Needless to say the technical meanings of these terms differ somewhat from the connotations which they carry in popular conversation. A hallucination is generally considered a positive entity—i.e., it is something people have. But according to Rosett it is an essential component of normal thought which appears only when the subject lacks a phylogenetically younger entity essential to

normal cerebration. But thought, imagery, and hallucination are not mutually exclusive classes—rather they are successive grades, and in the process of falling asleep and awakening the transition from one to the other is gradual and insensible.

There is a very finely divided index which covers 17 pages. A peculiar feature of the book is that among the 227 bibliographic references only 14, or less than 7 percent are to other works by the same author.



MENTAL DISORDERS IN URBAN AREAS. *An Ecological Study of Schizophrenia and Other Psychoses.*

By Robert E. L. Faris and H. Warren Dunham. University of Chicago Press, Chicago. \$2.50. $7\frac{1}{2} \times 5\frac{1}{2}$; xxxviii + 270; 1939.

This book presents a study of mental disorders by means of an ecological technique, that is, by an investigation of the "spatial character of the relations between persons who have different kinds of mental breakdowns." The site of the study is Chicago which is subdivided by the authors into nine areas distinguished by the predominance of a certain type of dwelling, as tenement and rooming houses, apartment houses (native-born, foreign-born, Negro), single homes, etc. Insanity rates for these different areas were then determined, based on first admissions to the Cook County Psychopathic Hospital for the two years 1930-1931. It is found that the highest rate occurs in the central business district, and that there is a steady decline in rates in travelling from the center of the city where the lower type of housing is found to the periphery where higher grade dwellings predominate. The different psychoses were next studied individually. The distribution pattern for schizophrenia, like that for insanity as a whole, is characterized by a high concentration of cases at and near the center of the city, with declining rates as the periphery is approached. Manic-depressive cases, on the other hand, show a definite tendency to come from a higher cultural and economic level. Alcoholism and drug addic-

tion show a pattern similar to that found for schizophrenia.

The authors have assembled an impressive and interesting array of material which is demonstrated graphically by a series of shaded outline maps of the Chicago area. A corroboratory study of the city of Providence, Rhode Island, is also reported. Details of the data are presented in tabular form in an appendix. A selected bibliography is given and there is an index.



THE STARTLE PATTERN.

By Carney Landis and William A. Hunt, with a Chapter by Hans Strauss. Farrar and Rinehart, New York. \$2.50. $8 \times 5\frac{3}{8}$; x + 168; 1939.

This book represents an attempt to study a basic, constant emotional response to a sudden emotional stimulus. Specifically, the startle response to the sound of a revolver shot was recorded by means of an ultra-speed moving picture camera, first for a group of normal adults, then for infants and children and for various types of psychiatric patients. It was found possible to define a characteristic, constant normal response, consisting of blinking of the eyes and general flexion of the body, completed in less than half a second and not affected by muscle tension, posture, or inhibition. This startle response is compared with the Moro response in infants and the conclusion reached that it is the more basic response, finally superseding the Moro. In schizophrenic patients the response was stronger than normal in the catatonic type, normal in other types. However, the immediate secondary behavior of the schizophrenic patients showed more flight and fear responses than normal. In the feeble-minded the response was found to be quantitatively stronger, but the pattern was qualitatively normal. The most striking deviation from the normal pattern was found in epilepsy where the response was weak, with the lid reflex frequently absent. Of particular interest is the observation that in hypnosis this apparently basic response can be suppressed.

This ingenious study has been carefully

done and is well presented. The results seem important, particularly in suggesting a new and objective type of approach to the little explored problems of affective behavior in human beings. There is a bibliography of 79 titles and an index.



LIFE WITHOUT FEAR.

By Peter Fletcher. Foreword by Percy L. Backus. E. P. Dutton and Co., New York. \$1.00. 7½ x 5½; vii + 111; 1939.

This small volume is dedicated to the thousands of unfortunates throughout the world who live and struggle under some form of personal fear, and is written in the hope that it may lead them to some measure of security, peace of mind, and general satisfaction with life. The author's analysis of the many psychoses resulting from fear and his suggested cures are well expressed in his own words,

... although I have been discussing what may properly be called psychological conditions, I have thought of them always as the manifestations of spiritual attitudes to life and its responsibilities; and wherever I have suggested any remedial measures, my emphasis has always been upon the necessity for a religious approach to the problem.

Fletcher's philosophy of life is shown by the following excerpts:

Life is in truth a spiritual adventure, and its true meaning is only to be discerned by those eager souls who are willing to forget themselves in the dangerous business of serving the purposes of God. . . . the way to peace for us will be by unflinching honesty with ourselves concerning ourselves, and a resolve to forget ourselves in the service of others; accepting the situation in which we find ourselves, and determining to make the best of it, not by any mental dodgery, but by courageous, resolute activity within the measure of our real capacities and in the reliance of God.

Our first impression is that Mr. Fletcher is a bit optimistic about man resolving to forget himself in the service of others (man being innately a selfish, non-social, and far-from-altruistic creature).



FRUSTRATION AND AGGRESSION.

By John Dollard, Leonard W. Dobb, Neal E. Miller, O. H. Mowrer, Robert R. Sears, in collaboration with Clellan S. Ford, Carl I. Hovland and Richard T. Sollen-

berger. Yale University Press, New Haven; Oxford University Press, London. \$2.00. 9 x 6; viii + 209; 1939.

In this publication from the Institute of Human Relations of Yale University, an attempt is made to reduce the relationship between frustration and aggression in human individual and social behavior to more or less predictable terms. Assuming as their basic postulate that aggression always follows frustration, the authors consider various corollary aspects of this relationship, such as degree of frustration, inhibition and displacement of aggression and the effects of aggression on the aggressor. The principles which emerge are discussed in subsequent chapters in relation to frustrations in American socialization and the regulations of aggression, and to adolescence, the period of intensified socialization. One chapter, devoted to criminality, contains a necessarily brief but excellent summary of pertinent present-day work. A rather speculative chapter considers frustrations under democratic, fascistic and communistic societies, and the gratifications which each guarantees. In the final chapter, frustrations in a primitive society are described. The style of the book is academic and the handling of the material somewhat cumbersome and a trifle dull, defects perhaps inherent in multiple authorship. There is a bibliography of 189 titles and an index.



THEORIES OF SENSATION.

By A. F. Rawdon-Smith. The University Press, Cambridge; The Macmillan Co., Co., New York. \$2.75. 8½ x 5½; xiii + 137; 1938.

The special senses of man are of incalculable value to him in adjusting himself to his environment, yet the exact knowledge of how these senses operate has remained meagre, and confined almost entirely to the realm of speculation. The author has gathered into this book all the available experimental data pertinent to vision and audition, and has discussed them in relation to the latest theories of sensation. Section I presents, in some detail, a discussion on the anatomy of the

eye together with the theoretical mechanisms that account for the eye's discrimination of intensity of light, color, and distance of objects. The section on hearing deals with the anatomy of the ear in relation to the perception of pitch and intensity of tone.

In many instances there are conflicting views as to the value of a particular theory, and in these cases, the author presents both sides of the question, together with a statement of his own opinion, based on the results of recent experimentation.

An extensive bibliography and a complete index are valuable assets of this fine volume.



BIOGRAPHIES OF CHILD DEVELOPMENT.
The Mental Growth Careers of Eighty-Four Infants and Children. A Ten-Year Study from the Clinic of Child Development at Yale University.

Part One by Arnold Gesell. Part Two by Catherine S. Amatruda, Burton M. Castner and Helen Thompson. Paul B. Hoerber, Medical Book Department of Harper and Bros., New York and London. \$3.75.
9½ x 6½; xvii + 328; 1939.

The authors of this study have traced the mental-growth careers of eighty-four infants and children over a period of ten or more years. In presenting these cases from their huge clinical records which run well into the thousands, the authors have mainly selected those cases which expose the difficulties and pitfalls of clinical diagnosis and prognosis and which are especially significant in clinical application and developmental psychology. The eighty-four mental-growth cases are presented not as brief impersonal case histories, but as individual biographic sketches. The authors stress throughout the book the possibilities of predicting mental-growth trends and the difficulties incurred in such predictions in atypical cases.

Part I deals with a review and follow-up of those cases which were published in a previous volume; Part II deals mainly with cases involving social and guidance problems.

A list of basic manuals and source

books is given for readers and students not familiar with the clinical methods used in these developmental examinations.



PSYCHE UND LEISTUNG DER TIERE.

By Werner Fischel. Walter de Gruyter und Co., Berlin. RM. 15. 9 x 6½; vi + 290; 1938.

This is an exposition of animal psychology on the basis of the present state of scientific research by the director of the research institute of the zoological gardens in Münster. All the incident problems are thoroughly discussed and possibilities set forth for further experimental investigations. Inasmuch as an accurate knowledge of animal psychology is of importance for a proper conception of the psychical factors in man, the book will prove to be of great value not only to the biologist and zoologist, but likewise to the psychologist, psychiatrist, philosopher and educator, whether theoretical investigator or practitioner.

There are 105 illustrations, an extensive bibliography, and indices of topics and names.



LECTURE DEMONSTRATIONS FOR GENERAL PSYCHOLOGY.

By Norma V. Scheidemann. University of Chicago Press, Chicago. \$2.50. 7½ x 5½; x + 241; 1939.

This book represents a compilation from the psychological literature of 60 tests and demonstrations used by recognized psychology teachers in the classroom to elucidate points covered in their lectures. Each demonstration is described concisely with regard to purpose, material, procedure, and points of interest to the class. A brief summary of previous experience with, and conclusions from, each demonstration is given. The selection of demonstrations seems excellent, and the book should be of practical interest to all teachers of psychology.



THE TROUBLED MIND. *A General Account of the Human Mind, and Its Disorders and Their Remedies.*

By Harry Roberts. With chapters on the Insanities by Margaret N. Jackson. E. P. Dutton Co., New York. \$2.00. 7½ x 5½; [4] + 284; 1939.

This discussion of mental functions and of present-day viewpoints in psychology and psychiatry is designed for the layman and is to be recommended as a sensible, accurate and thoroughly pleasant piece of work. The first half of the book deals with normal psychobiological mechanisms, the second half with a brief discussion of the most common neuroses and psychoses. Chapters are devoted to the types of treatment available, and to existing legalities for protecting the mentally ill. The information covered is that with which every intelligent layman should be familiar, and this book offers a reliable source. There is a brief index.



THE NINETEEN THIRTY EIGHT MENTAL MEASUREMENTS YEARBOOK OF THE SCHOOL OF EDUCATION OF RUTGERS UNIVERSITY.

Edited by Oscar K. Buros. Rutgers University Press, New Brunswick, N. J. \$3.00. 9½ x 6½; xiv + 415; 1938.

The *Mental Measurements Yearbook* is a comprehensive and systematic review and criticism of mental tests and books on mental tests. The book is frankly critical and starts with the assumption that "... ninety out of every hundred tests published in the United States should be withdrawn because they have never been satisfactorily validated and standardized." The value of the book is greatly enhanced by the cooperative reviewing of over a hundred specialists in the field of testing. This *Yearbook* is a "must have" for all those operating in the field of mental testing.



DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

WHENCE? WHITHER? WHY? *A New Philosophy Based on the Physical Sciences.*

By Augusta Gaskell. Introduction by F. K. Richtmyer. G. P. Putnam's Sons, New York. \$2.50. 8½ x 5½; 312; 1939. The late Augusta Gaskell was a remark-

able woman. To an original, clear, and vigorous mind she added an indomitable energy that was never daunted by difficulties. In her lifetime she accomplished an amount of work that was literally prodigious. Perceiving that the development of her ideas required a sound knowledge of a wide range of science in its most recondite branches she proceeded, by the simple process of hard, patient labor, to get that knowledge. Short cuts never interested her. Nor did anything intellectually cheap, smart or dishonest. No personal sacrifice was too great if it would help in the steady progression of her work.

The major objective of Mrs. Gaskell's life was to produce two books—*What is Life?* and *Whence? Whither? Why?* The present volume, essentially finished just before the onset of her last illness, marks the accomplishment of this objective. It will be noted that the titles of both books are *questions*. This is not accidental. Mrs. Gaskell was as far removed as it is possible to conceive from either the dogmatist or the propagandist. She was just curious to find truth. The present volume sets forth the conclusions she had tentatively reached about the oldest and greatest of philosophical problems—the meaning of human existence. We agree with, and cannot improve upon, the estimate of the book that Prof. Richtmyer gives in his *Introduction*.

Granted the correctness of her statements of factual knowledge, there remains the evaluation of her philosophical arguments and conclusion. From the very nature of the case, each reader must make this evaluation for himself. The critical, thinking, yet sincere, reader will of course find much to criticize. He may think occasionally that the evidence upon which arguments are based is inadequate. He may disagree here and there with statements and conclusions; perhaps with now and then a whole chapter. Those philosophers, professional or amateur, secular or religious, who have already formulated opinions and conclusions which approach the subjectively dogmatic, probably will not only be unconvinced but, following natural human traits, will set out to prove that Mrs. Gaskell is wrong. Some may think that her efforts are not worth even that attention.

However, the reader who approaches Mrs. Gaskell's book with an open mind will find it interesting, stimulating and thought-provoking—which should be the main objectives of any book of this kind.



A HISTORY OF SCIENCE, TECHNOLOGY, AND PHILOSOPHY IN THE EIGHTEENTH CENTURY.

By A. Wolf. *The Macmillan Co., New York.* \$8.00. 9½ x 6; 814; 1939.

This is a scholarly piece of work. The author had already established a reputation with a similar book dealing with the two preceding centuries, and the present work is well worthy of its predecessor. It is a treatise of encyclopedic proportions covering not only science *sensu lato*, but philosophy as well. The discussion of the latter falls into place quite naturally after that of the social sciences, which, since their precepts are not amenable to laboratory experimentation seem more closely affiliated to philosophy than to the physical and biological sciences, and consequently form an effective link between the two.

Prof. Wolf seems to be equally at home in either science or philosophy, and his writing exhibits none of the frictional jealousy that sometimes appears when a writer attempts to cover both fields. He has accomplished a highly significant account of human learning in the 18th century. The illustrations are splendid, the index detailed and adequate, and it is to be hoped that companion volumes dealing with the later centuries may soon come from the same pen.



PHOTOGRAPHY, ITS PRINCIPLES AND PRACTICE. *A Manual of the Theory and Practice of Photography. Third Edition.*

By C. B. Neblette. *D. Van Nostrand Co., New York.* \$6.50. 9 x 6; xi + 590; 1938.

Photography is intended as a textbook on the subject and assumes that the reader has a knowledge of chemistry and physics. It presents in descriptive and mathematical terms the qualities associated with different types of lenses, and in conjunction the exposure which must be allowed in each case. Likewise the author deals with the chemical processes involved in preparing emulsions, developing, and fixing. Aside from the purely technical aspects of photography, the amateur can learn much from these pages. An interesting history of the subject is given in the opening chapter. Practical methods are presented for developing, printing,

enlarging, mounting, and retouching. A particularly useful chapter is that on negative defects, teaching the photographer wherein his errors lie. It is a very complete manual, well indexed, and containing extensive references.



BIOLOGY AND CHRISTIAN BELIEF.

By William O. Greenwood. Foreword by Theodore Savory. *The Macmillan Co., New York.* \$1.75. 7¼ x 5¼; 192; 1939.

The author, in revealing the natural wonders of the universe, shows life to be a "web on the loom of time," God being the Divine Weaver. But his arguments have the stability of a spiderweb woven to a swinging barroom door. Talking first of physical things, Dr. Greenwood mentions the size and weight of atoms, but a few pages later says of them, "Waves and disturbances are all we find and, . . . on the very threshold of our inquiry, while we attempt to extract some meaning from the very elementals, we are met with the arresting suggestion that, lying at the heart of the apparently material, is the presence of what we must call spiritual." This book like many others of its ilk, uses the argument that since science cannot demonstrate how the universe originated, the only thing that offers any rationality is a creative act of a master mind.



WHAT'S TO FOLLOW? *A List of Books on Cookery in the Oxford City Libraries.*

Oxford City Libraries, Oxford. Foreword by Mrs. C. F. Leyel. 7¼ x 5; 15; 1939 (paper).

This little handbook giving the "list of books on cookery in the Oxford [England] City Libraries" we find entertaining. In the foreword Mrs. Leyel recalls the maxim of George Birmingham's Irish curate, who held that it doesn't matter what you feed a child on "as long as you give it enough of whatever it is you do give it." The books (153 in number) are listed under various headings. A number of them are known to Americans but many, of course, are not. Added

interest is given by the inclusion of a few choice local recipes: e.g., an eighteenth-century trifle "frequently used in Oxford," Oxford sausages, Banbury cakes, wassail "a very old cup which used to be drunk at Jesus College, Oxford" and an old Burford recipe for dandelion wine.



SCIENCE IN AFRICA. *A Review of Scientific Research Relating to Tropical and Southern Africa. Issued by the Committee of the African Research Survey under the Auspices of the Royal Institute of International Affairs.*

By E. B. Worthington. Oxford University Press, London, New York and Toronto.

\$4.00. 8½ x 5½; xiii + 746 + 7 plates + 2 folding maps; 1938.

This volume is a report of the African Research Survey. Its eighteen chapters cover practically all the geological and biological sciences though in some instances rather inadequately; e.g. the pseudohaline fauna of Lake Tanganyika, the oldest and second deepest lake in the world, is dismissed in a single sentence. No mention is made of the pioneers Burton, Speke, Bourguignat, or Edgar A. Smith, and Livingstone is mentioned only once.

The index comprises 56 pages, the bibliography 65, and the acknowledgements 11, so that despite the lack of information in the specific instances mentioned above the book is nevertheless full of essential material concerning African science.



EDUCATIONAL FOUNDATIONS.

By the late J. Lionel Tayler. Edited, with an Introduction by H. Salmon. J.

W. Sparks, London. 3s. 8½ x 5½; 176; 1939.

These posthumously published essays of the late Lionel Tayler deal, from a broad point of view, with the relations between biology and education. They are edited by H. Salmon who added an introductory chapter on social education. The essays cover a great variety of matter worth reading but difficult to review briefly, such as the biological interpretation of life, the biological ideal of education, educational foundations as a study of motives, adolescence and the birth of ideals, education and the national welfare as a scheme for the stages of life. The manifold subjects broached in the different essays will probably find many interested readers among biologists and sociologists.



THE STORY OF A FACE.

By Hillary G. Bailey. Camera Craft Publishing Co., San Francisco. \$2.50.

9½ x 6½; 127; 1938.

CHAMPLIN ON FINE GRAIN.

By Harry Champlin. Ibid. \$2.00. 7½ x 5½; 154; 1938.

MODERN PORTRAITURE.

By Stanley R. Jordan. Ibid. \$3.00. 8½ x 6½; 199; 1938.

PRINT FINISHING.

By William Mortensen. Ibid. \$2.50. 9½ x 6½; 128; 1938.

SNOW AND ICE PHOTOGRAPHY.

By H. W. Wagner. Ibid. \$1.00. 7 x 5½; 96; 1938 (paper).

COMMERCIAL PHOTOGRAPHY WITH THE MIN-IATURE CAMERA.

By C. A. Goldner. Ibid. \$1.00. 7½ x 5½; 95; 1939 (paper).



THE QUARTERLY REVIEW of BIOLOGY



THE DISCOVERY OF THE CELL OF SCHWANN IN 1839

By FRANCIS TH. MÜNZER, M.D.

Docent of Neurology, German University, Prague

"Even though to aspiring Youth, bent on the creating of nothing less than a new World-epoch, the past appears irksome rather than inspiring, nevertheless those of riper mind and years must often accord their grateful recognition to the manifold Good and Useful and Helpful that they have inherited from their Ancestors" Goethe, *Materialien zur Geschichte der Farbenlehre*

I

IN 1839 Theodor Schwann (1), in his famous *Microscopical Researches into the Accordance in the Structure and Growth of Animals and Plants*, described for the first time those cells of the peripheral nerve fibers which ever since have been known by his name. Schwann also endeavored to grasp their origin and meaning, and as the fruit of his efforts conceived the so-called cell-chain theory of the development of nerve fibers. He thus became the creator of a hypothesis which was to find many adherents, and which has to the present day retained some of its former importance. Other hypotheses have indeed been advanced since, of which mention may be made of the outgrowth theory, as advanced by Kupffer

and Bidder, and Hensen's protoplasmatic-bridge theory.

So it may seem not inappropriate, if, on the hundredth anniversary of the first description of the Schwann cell, due homage is paid to its discoverer by a commemoration of what he achieved in the field of neuro-histology.

Theodor Schwann, the fourth son of a bookseller, was born at Neuss on the Rhine on December 7, 1810. In 1829 he began to study philosophy and medicine, first at the University of Bonn and later at Würzburg and Berlin. From 1834 to 1839 he worked in Berlin—simultaneously with Jakob Henle—as an assistant to the physiologist Johannes Müller. In 1839 he was appointed professor of anatomy at the University of Louvain and nine years later went in the same capacity to Liege. From 1858 he also occupied the chair of physiology. In 1880 he retired from his academic activities, and died in Cologne on January 11, 1882.

At the age of twenty-nine he wrote his epoch-making *Microscopical Researches*,

which, in the words of K. Sudhoff (33), "represent a conspicuous milestone in nineteenth century biology," and he thereby ranks as one of the originators of the cell-theory.

As J. Henle (31) says in his necrology on Schwann, he applied himself as early as 1836-1839 to the problem of the regeneration and termination of the nerve fibers. But the sheath of Schwann and the Schwann nuclei, both of which are named after him, found their first description in the *Microscopical Researches*.

II

It is perfectly clear, however, that the investigations carried out by Schwann also denote a milestone in the history of neuro-histology. At no time before the appearance of the universal cell theory had an acceptable explanation been offered of the elements constituting the nervous system, and of their meaning. Here, for the first time, the idea was clearly formulated (and an attempt made to corroborate it by minute proofs) that the whole of the animal organism was built up by, and consisted of, nothing else but cells.

Theodor Schwann devoted a large part of his investigations to the nervous system of which the forms of elementary structure (*Elementargebilde*) presented themselves to him in a twofold manner: "1st, fibers, nervous fibers in the extended sense of the term, including the fibers of the brain and spinal cord; 2nd, globules, ganglion-globules, in addition to the ganglia occurring in the brain and spinal cord" (p. 141, 142:—This, like all the other quotations, are taken from the English translation by Henry Smith. *Vide Literature cited*, No. 1). To him the principal task of his neurological research work consisted in pointing out "the relation which these two forms of elementary structure bear to the elementary cells" (p. 142). Such an

enterprise at *his* time was bound to meet with the greatest difficulties, if concerned with nerve tissue, as it will still meet with certain obstacles today, when directed to the *peripheral* nerve fiber. Of such complications Schwann was perfectly aware, when he wrote: "In general, the higher the importance of a tissue is, the more do the cells lose their individuality" (p. 64).

He was the first to give an adequate explanation of the ganglion-globules by defining them as true cells. They are, in Schwann's own words "simple cells. The parenchyma of the ganglion-globules forms the cell-contents, and the vesicle in their interior is the cell-nucleus; the small corpuscles which it contains are the nucleoli. The vesicle of the ganglion-globules lies, as in other cells, eccentrically upon the internal surface of the cell-membrane. This cell-membrane may be most distinctly observed in the ganglion-globules of the sympathetic nerves of the frog, previous to their junction with the sacral plexus. [See Fig. 1a—I am greatly indebted to Miss H. Rauchberg for her most faithful copies of this and the following figures from the originals.] It there appears comparatively dark, and sharply defined, both externally and internally, so that its thickness may be readily measured" (p. 153).

But Schwann, rather oddly, appears to believe that "in the situation before mentioned in the frog, it seems as though a ganglion-globule were sometimes formed within another cell" (p. 153) and, as a reason for his assumption, refers to Fig. 10b (our Fig. 1b), which, however, is an obvious case of shrinkage.

In accordance with Robert Remak, he distinguishes between two different forms of nerve fibers: (a) the *common white nerve fibers*; (b) the *gray*, or so-called *organic fibers*.

The white color of the *white* dark-

edged nerve fibers is conceived by Schwann as being caused by the same substance which, "when examined microscopically, exhibits very dark margins." "The margin of a fiber generally presents a double outline on both sides, so that it has the appearance of a hollow tube, and the distance between the two outlines, then, denotes the thickness of the white substance" (p. 142). The axis cylinder had been previously singled out by Remak. Schwann continues: "According to the researches of Remak, the white substance of every nervous fiber may be removed by pressure, and an extremely pellucid, pale

namely, the above-mentioned band" (p. 142).

The pertinent passage describing the *sheath*, since known by his name, and *its nuclei*, runs as follows:

It seems that the expression *neurilemma*, to denote the sheath of Schwann, had its origin with E. Reissner (30), while most earlier authors had applied this term to the connective tissue (epineurium) enveloping the nerves, the lamellae (perineurium) radiating thence into the interior, and the tender tracts of connective tissue (endoneurium) occurring within the minor nerve stems. The relating passage by Reissner (p. 726) reads: "The hardened, carmine-stained and turpentine-cleared preparations of cross-sectioned nerve fibers display the crimson primitive sheath, which I call neurilemma because of its correspondence with the sarcolemma, the axis cylinder, mostly in the same color, and the transparent myeline, which as a rule remains colorless."

"The white substance of each nerve is surrounded externally with a structureless and peculiar membrane, which appears to be minutely granulated. This membrane presents itself as a narrow, clear border, which is really distinguished from the dark contours of the white substance. This membrane seems hitherto to have been included with the neurilemma or with the cellular tissue, which surrounds the nervous fiber, and although its external outline is generally very sharply defined in the nerves of the frog, it would be difficult, on examination of the entire nerve of a mammal, to arrive at any conviction of its distinct and separate existence, did not opportunities of observing it in an isolated state present themselves. Pl. iv, fig. 9a [our Fig. 2a] represents such a preparation, taken from the cranial portion of the nervus vagus of a calf. The continuity of the white substance has here been broken by the process of preparation; but where it still exists, the double contours, (and thus the thickness of the white matter), may be clearly distinguished. But the nerve still exists at the part where



FIG. 1. GANGLION-GLOBULES FROM THE LOWEST GANGLIA OF THE SYMPATHETIC OF A FROG. Magnified about 450 diameters, linear measurement. After Schwann (1), Plate IV, Fig. 10.

band, which was previously surrounded by the white substance, then remains, corresponding to that which, previous to the manipulation, seemed to be the contents of the tube. . . . Two opinions with respect to the nervous fibers may be deduced from the above observations; either this pale band is the proper nervous fiber, and the white substance only a sheath (cortex) around it (this is the view taken by Remak), or the nervous fiber is actually a hollow fiber, the wall of which is formed by the white substance, the contents of which, however, are not fluid, but composed of a tolerably firm substance,

the white substance is separated, its sharply-defined external margins may be seen, although their contours are but pale, and it may be observed that this pale outline does not pass into the external dark one of the white substance, but is continued on the outside of it as a narrow border, parallel to the two outlines of the white substance. The white substance of nerve is, therefore, surrounded externally with a thin, pale membrane, which has a sharply defined external margin. If the

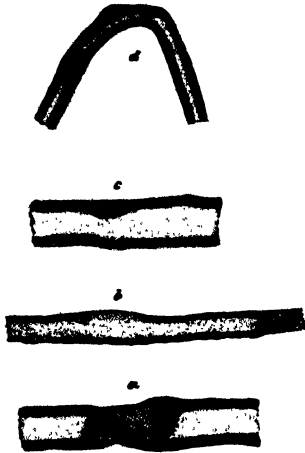


FIG. 2. NERVOUS FIBER FROM THE VAGUS OF A CALF
Magnified about 450 diameters, linear measurement.
After Schwann (1), Plate IV, Fig. 9.

membrane be very thin, it cannot be recognized as the pale border round the nervous fiber; it is still, however, distinctly visible at situations where the white substance is destroyed. (See fig. 9, *b* [our Fig. 2 *b*]). The mere fact of the membrane possessing a defined external border, is evidence against its being composed of areolar tissue; and even the portion which does not contain any white substance, presents no appearance of a fibrous structure; it simply appears to be somewhat minutely granulated. If this be correct,

the membrane can have no other signification than that of cell-membrane of the nervous fiber, or secondary nerve-cell. The white substance is then a secondary deposit upon its inner surface. The position of the cell-nuclei is also favorable to this view" (p. 146, 147).

As to the nuclei, he gained the impression that most of them disappear on the increasing development of the white substance: "Some, however, appear to remain for a longer period; occasionally, although rarely, a cell-nucleus is here and there seen upon the side of a nerve (the white substance of which is completely developed), lying in the pale border, which surrounds the white substance. Fig. 9, *c* and *d* [our Fig. 2, *c* and *d*], exhibits them from the nervus vagus of a calf. At *c* the white substance, corresponding to the nucleus, even forms a slight projection into the cavity of the fiber. This nucleus seems therefore actually to belong to the fiber, and to lie upon the inner surface of the cell-membrane, while the white substance is so deposited, that the nucleus remains situated external to it. The band discovered by Remak would then be the proper cell-contents" (p. 147).

Schwann also came to believe that the relation between the myeline-sheathed nerve fibers and the cells would have to be elucidated by the *history of their development*, and he examined the formation of the nerve fibers in the foetal pig. Completing and continuing the studies of Remak he reports that the nerves of the foetus "have not the shining white colour, presented by those of the adult animal, but are gray and transparent, and the younger the embryo the more striking are these appearances" (p. 143). The greater part of the nerves in a foetal pig of about six inches in length "does not form connected fibers, but consists of separate round globules"—Schwann regarded these struc-

tures "as an artificial product, caused by pressure and the action of water upon the as yet very delicate nerve" (p. 148) "— or more or less long, irregular little cylinders, arranged with their long axes in the direction of the course of the nerves, having outlines, however, quite as dark as those of the nervous fibers. . . ." "In addition to them, however, a substance of quite another appearance is seen, which has not the dark outline, does not appear pellucid but granulated, and in which the *cell-nuclei* [my italics] are distinctly rec-



FIG. 3. (A) PORTION OF THE ISCHIATIC NERVE OF A FOETAL PIG MEASURING FOUR INCHES. (B) FASCICULUS OF NERVOUS FIBERS FROM THE BRACHIAL PLEXUS OF THE SAME. After Schwann (1), Plate IV, Figs. 6 and 7.

ognisable." ". . . When the other constituent parts predominate, the nuclei may very probably be overlooked, or possibly be regarded as extraneous substances" (p. 143, 144).

"The development of nerve, however, does not appear to proceed uniformly in all individuals; for the dark globules and cylinders were already present in some other pigs' embryos, which were scarcely any larger. Pl. 4, fig. 6 [our Fig. 3 A] represents a portion of the ischiatic, and fig. 7 [our Fig. 3 B], of the brachial nerve of such a foetus. We observe a palish,

and very minutely-granulated cord, which, in consequence of certain longitudinal shadings, such as the delineation exhibits, presents the appearance of a coarse fibrous structure. Round or for the most part oval corpuscles, which are immediately recognized as cell-nuclei, and which sometimes also contain one or two nucleoli, are generally seen in the course of these shaded parts, throughout the entire thickness of the cord. Sometimes a fiber separates from such a cord, and stands out isolated, as at *a* in both the figures, and the nuclei are then seen to lie in the course of the fibers. A single fiber presents several nu-



FIG. 4. SINGLE NERVOUS FIBERS. *a*, FROM THE NERVOUS TRIGEMINUS OF A FOETAL PIG MEASURING SIX INCHES AND A HALF; *b*, *c*, *d*, FROM THE NERVOUS ISCHIADICUS OF THE SAME. After Schwann (1), Plate IV, Fig. 8.

clei in its course, as was also observed in secondary muscle-cells" (see Fig. 4 *b*). ". . . Although the (nervous) fibers cannot at this early period be distinctly perceived to be hollow, the wall not being distinguishable microscopically from the contents, yet we shall see that the progress of development renders it highly probable that they are so" (p. 144).

Schwann supposes, on the analogy of the development of the muscle-cells, that the nerve fibers "are formed by the coalescence of primary cells, to which the nuclei, just noticed as present upon the fibers, have pertained; so that thus the nervous fibers would be secondary cells, corre-

sponding to the secondary muscle-cells, or primitive muscular fasciculi. The actual observation of the primary cells of nerve in their independent state, is very difficult, from the circumstance of our being unable at that period to distinguish between them and the surrounding tissues; for a whole organ is then composed entirely of independent cells, which have not as yet undergone any transformation. It is true," he writes, "I saw an independent cell, furnished with a nucleus, which seemed to have separated from the nervous cord, in one of the preparations alluded to, fig. 6, *b* [our Fig. 3 A, *b*]; but I cannot positively assert that it had actually separated from that particular part, nor that it was a primary nerve-cell, for the cells in that preparation had not as yet undergone any change. In this instance, therefore, we must content ourselves, for the present at least, with the analogy to muscle" (p. 144, 145).

"These fibers, or secondary nerve-cells, differ very much in their appearance from the subsequent nervous fibers, which are furnished with distinct but not dark outlines; they have a pale, granulated aspect. By progressive development, however, they become converted into the white fibers, and pl. iv, fig. 8, *d* [our Fig. 4, *d*] represents the transition. The part of the figure to the right hand exhibits the fiber yet in the early condition, pale, granulated, and furnished with a cell-nucleus; in the portion to the left, it has completely assumed its subsequent form: it has a dark outline, is not granulated, and the one portion passes immediately into the other. The identity between these pale fibers and the subsequent white nervous fibers is thus established" (p. 145).

The transformation of the granulated fibers into the white nerve fibers consists in the "development of the white substance." This process could, in the opin-

ion of Schwann, be explained in a three-fold manner: "It may take place, 1stly. By the white substance forming as a sheath (cortex), around each fiber, and in this manner enclosing it. By this mode of explanation the fiber would be identical with the pale band discovered by Remak, which would therefore be the cell-membrane itself. 2dly. The white substance might be regarded as a transformation and thickening of the cell-membrane of those fibers, or secondary nerve-cells. According to this view, the white substance would be the cell-membrane, and Remak's band the firm contents of the secondary cell. 3dly. The white substance may be formed as a secondary deposit upon the inner surface of the cell-membrane, being chemically distinct from the latter, and the remainder of the cell-cavity may then, and not until then, become filled up by Remak's band" (p. 145, 146).

Personally, Schwann inclines to, and advocates, the third view; he holds that the myeline is a secondary deposit on the interior surface of the cellular membrane.

"According to the foregoing explanation, therefore, each nervous fiber is, throughout its entire course, a secondary cell, developed by the coalescence of primary nucleated cells. With respect to these cells, we remark, 1stly. An external, pale, thin cell-membrane, having a granulated but not a fibrous aspect, the inner surface of which constantly exhibits cell-nuclei in the very early period of the development of nerve; but in the somewhat more advanced stage, when the white substance is developed, they are only occasionally found. 2dly. That the white, fat-like substance to which the peculiar appearance and distinct outline of the nerves are chiefly referable, is deposited upon the inner surface of this cell-membrane. When this deposit is thick, its double contour (to which the nerve is

indebted for its tabular appearance), may be recognized; this, however, escapes observation when only a thin stratum of white substance is present. Morphologically considered, it therefore corresponds to the peculiar substance of muscle, for that is likewise developed as a secondary deposit upon the membrane of the secondary muscle-cell. 3dly. That the rest of the cell-cavity appears to be filled up by a firm substance, namely, the band discovered by Remak. There seems to be no structure analogous to this band in perfectly-developed muscles, for there, the secondary deposit, that is, the formation of the proper muscular substance, proceeds until the cavity of the secondary cell is completely filled" (p. 147, 148).

As regards the *gray*, or *organic nerve fibers*, Schwann has nothing to add to the description given by Remak (cf. particularly Remak, 14, p. 5) with whom he almost wholly agrees. The corpuscles (*Körperchen*) attached to those fibers, which had been observed by Remak, he recognized at once as cellular nuclei. He also pointed out a certain resemblance between the organic fibers and "the earlier condition of the white nervous fibers, as they were represented in pl. IV, fig. 8, *a*, *b* [our Fig. 4, *a*, *b*]. Both have the same pale, minutely-granulated appearance, and both present cell-nuclei in their course. The only difference is, that the organic fibers are much more minute and the nuclei smaller. Each single nucleated organic fiber . . . corresponds to a white primitive fiber, and is probably, like it, a secondary cell, which has been generated by a coalescence of primary cells, whose nuclei are the nodules described by Remak as existing upon these fibers" (p. 151, 152).

The continuation of this passage runs as follows: "The similarity between the organic fibers and that which I have described as the earlier condition of the white nerve fibers, might be adduced as an

objection to my description of the formation of nerves, and it might be said, that that form seemed to be the earlier form of the white nervous fiber, because the organic nerves were developed earlier than the white, and, therefore, organic fibers were the only ones present in the first instance. Observation of the actual transition, as represented in pl. IV, fig. 8, *c*, *d* [our Fig. 4 *c*, *d*], would, however, refute this argument. Each pale, nucleated fiber becomes a white nervous fiber, as an immediate consequence of the formation of the white substance, which is probably a secondary deposit upon the internal surface of the hollow fiber. The information of this white substance, which, according to analogy, must occur in every one of the minutest fibres, either does not take place at all in the organic fibres, or does so at a much later period, and their peculiarity therefore consists in their remaining stationary at an earlier stage of development, and either never attaining to the higher development of ordinary nerves, or only at a much later period, (a point which might be decided by comparing their numbers in old and young individuals). One can conceive that the function of the organic nerves, whether it be actually a chemico-vital one, or consist merely in the production of involuntary motion, requires less-developed nerves, in the same way that the involuntary muscles do not attain the same degree of development as the voluntary."

Summing up his view on the origin and development of nerves, Schwann concludes: "The growth of nerves neither proceeds from the circumference towards the central organs, nor *vice versa*, but their primary cells are included amongst those from which every organ is formed, and which, so far at least as their appearance is concerned, present no marks by which they can be distinguished from other cells. They are first characterized as nerves, when they become arranged in rows and coalesce to form a secondary cell. After that coalescence each nervous fiber forms a separate cell, which pursues an uninterrupted course from the organ, in which its peripheral extremity is situated, to the central organ of the nervous system" (p. 149).

Having reproduced here in his own words, whenever possible, such passages

of Schwann's treatise as might prove of any moment or interest to neurologists and neuro-histologists, we think that the importance of these observations will afford a sufficient justification for quoting them. Still there remains the striking fact that to the question of the relation between ganglion cell and nerve fiber—which even as early as in his time had undergone a certain amount of discussion—Schwann never paid the slightest attention.

III

Today it is impossible to gauge or to realize the tremendous achievement accomplished by Schwann and the inherent importance of his discovery, unless we take into account the state of such contemporary knowledge as existed before the appearance of his *Researches*. That is why a terse, roughly sketched outline of its historical development, from the discovery of nerve fibers and nerve cells up to the time of Theodor Schwann, may be permitted at this juncture.

I think there is good reason why the reader's attention should be drawn to those fundamental publications which, though most of them have long been forgotten, are nevertheless noteworthy for having impressed their stamp upon the early development of neuro-histology. In the interests of objectivity, I would add that the originals of the most important works have been at my disposal. Those who work in the field of neuro-histology may well profit by a fuller acquaintance with the soil they help to cultivate; for only thus can be seen the earlier yield—and the defects of the soil. In this way it is easier to understand why certain erroneous notions pass like an inheritance from one generation to another; how certain terms, once they have taken root, perpetuate their influence—I need

merely mention expressions like: nerve tubes (*Nervenröhren*), nerve sheaths (*Nervenscheiden*), myeline sheath (*Markscheide*). Such terms, however, which can only be understood in the light of their origin, appear inappropriate and liable to form a hindrance to further progress—as will appear in my forthcoming publication.

We cannot say with any certainty who was actually the first to observe the myelinated nerve fibers. There is a common supposition that they were discovered by the Italian physician Felice Fontana (4) (born on April 15th, 1720, at Pomaroli near Rovereto, died on February 9th, 1805, at Florence) who, in 1781, from observations made on tease preparations described the peripheral nerves as being "composed of transparent, homogeneous, uniform, very simple, cylinders" (p. 371:—This and the following quotations are translated from the German edition of Fontana's book, which appeared in 1787; Literature cited, No. 4, b).

Now it is quite true that, according to the statement of Fontana himself (4, p. 357), as early an observer as Antonius van Leeuwenhoek (1632-1723), the originator of microscopical anatomy, is said to have noticed the fibrillar structure of nerves, and, on microscopical examination of a very delicate nerve no thicker than a hair, to have counted sixteen *small nerve tubes* (*Nervenröhrchen*), very distinctly margined and filled with transparent contents. Leeuwenhoek seems to have maintained the view that those small nerve tubes consisted of nothing but a membrane of liquid contents. His statement, however, was contradicted by almost all subsequent investigators, who—obviously on inspecting heavily crushed nerves under water—could not see anything but a mass of granules and globules, which they took for the ultimate elements of the nervous system. But the

great physiologist A. von Haller had already displayed great reticence in his criticism of those observations of the nerve structure, and admitted that "nothing but mere conjectures could be offered on this subject. He was, however, inclined to believe that there might exist in the nerves some kind of tubular structure" [cited according to Fontana (4 b), p. 357].

Fontana also mentions the names of two contemporary observers, who engaged in microscopical research of the nervous system: Father Della Torre (2) and Professor Prochaska (3) of Prague. But their statements damaged more than

methodical research was able to establish that "the nerves appear to be composed of filaments, parallel and sinuous, just as they are shown in" (p. 365) the drawing here reproduced as Fig. 5.

Those single fibers or cylinders, of evenly uniform thickness, wavily and sinuously arranged within the nerve, when observed "to be more or less transparent, composed of small pellicles, and partly filled with a gelatinous, pellucid humor and small globules or irregular corpuscles" (p. 368). For these cylinders Fontana introduced the term *original nerve cylinders*

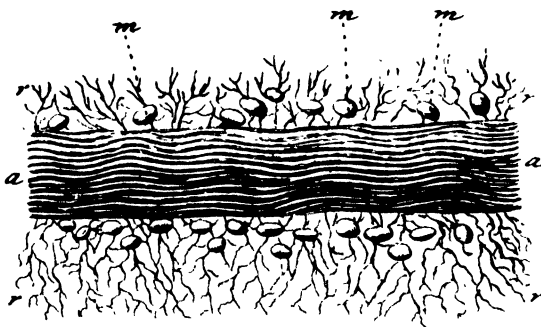


FIG. 5. FIGURE ILLUSTRATING A NERVE COVERED WITH ITS CELL-TISSUE, AS IT APPEARS THROUGH A VERY FEEBLE LENS. *aa*, THE TWO NERVE ENDS, *m*, OVAL GLOBULES WHICH MAY BE OBSERVED WITHIN THE CELL-TISSUE, *r*, FIBERS OF THE CELL-TISSUE FLOATING IN THE WATER
According to Fontana 4, Plate III, Fig. 11

they advanced the progress of science, "for they spread the erroneous notion of the brain being a pulpy mass that consisted of granules floating in a sticky, clear colored liquid, and partly lying side-by-side here and there." [Quoted from Ehrenberg (6, p. 448 449), who quite rightly attributes Della Torre's statement to the fact that "on being examined between mica scales or glass plates, the brain substance had been subjected to pressure which was either too strong or too weak."]

The greater, therefore, is recognition due Fontana, who by obviously quite

("Ursprüngliche Nervencylinder"), "for it is these parts which make up the nerve, or its marrowy component" (p. 368). In his opinion the cylinders consist of *two* component parts: "The one is quite outside, rugged and irregular; the other is a cylinder, apparently formed from a particular, transparent skin, which is filled with a gelatinous humor of some consistency" (p. 370); cf. Fig. 6.

Fontana, therefore, distinguished in the nerve fibers between the cylinder which is composed of the *skin* and this skin's *contents*, and the encasing sheath which is composed of *serpentine* filaments (cf. Fig.

6 B). For this sheath he introduces the term serpentine cylinder (*geschlängelte Cylinder*). It is obvious from his drawing and description that he deals here with what is known today to be collagenous connective tissue.

Of the original cylinders, which were his own discovery, Fontana assumed that "they were the simple and primary organic elements of nerves" (p. 371).

The results of what he observed in the cortical and white substance of the brain, of which nothing had been known up to his time except the vessels,—the distinc-

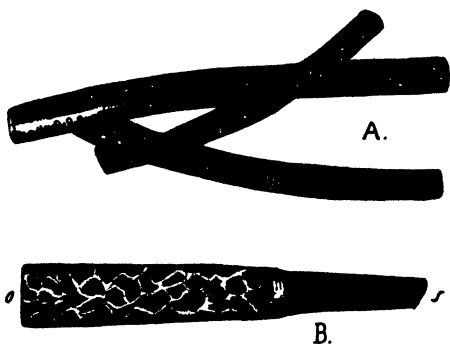


FIG. 6. ORIGINAL NERVE CYLINDERS. (B) REPRESENTING AN ORIGINAL NERVE CYLINDER, WITH *a-f* SHOWING THE THICKEST PART WHICH IS COVERED WITH A THIN FIBERED CELL-TISSUE; THE PART *r-s* BEARS NO SUCH CELL-TISSUE
After Fontana (4), Plate IV, Fig. 3 and Fig. 7.

tion between cortical and white substance in the brain being most probably attributable to Vesal—are of much less importance than what he has to say of the peripheral nerves. Thus he speaks of a gut-like (*darmähnlichen*) structure of white substance, which probably means that he imagined that he observed that the latter, on greater enlargement, "in reality appeared to be composed of an assembly of small, irregular bowels, sinuous, transparent, and filled with a gelatinous humor" (p. 373). These small bowels were of extreme shortness, and some of them

terminated in globules. The structure of the cortex would thus not be essentially different from that of the white brain-substance. Because of its historical interest the corresponding drawing by Fontana is reproduced here together with the original wording (Fig. 7).

It is remarkable that even the problem of the regeneration of peripheral nerves should have been drawn into the orbit of the research work instituted by Felice Fontana. He confirmed the experiments of Cruikshank who, according to Fontana (p. 350 *sqq.*), as early as 1778 and 1779, in experimenting on a dog bisected the eighth pair of spinal and intercostal nerves: these subsequently regenerated. Fontana realized by his own microscopical observations—and he even augmented them—that "not only do nerves unite again, if severed by a cut, but even if a piece of some length be excised. In the first instance, there ensues a true reunion of the parts, a true connection of the substance—in short an uninterrupted continuity of the original nerve cylinders and the skins which cover them. In the second instance, the nerve regenerates by itself; i.e. the nerve substance increases at both ends and by elongating, meet again, and form a homogeneous, connected and uniform whole" (p. 355).

No further progress can be recorded until the work of Gottfried Reinhold Treviranus (5) who, in an essay—published in 1816—*On the Organic Elements of the Animal Body*, confirmed the views of Fontana and also substantially supplemented them. Treviranus held that the nerve fibers were "skinny tubes which were filled with a tough matter, the myeline (*Nervenmark*) proper, and were held together in bundles by sheaths of cellular tissue" [cited, according to Henle (21), p. 776]. Contrary to Fontana, however, he found at the cylinders only *one* single skin, down the

interior surface of which there ran *serpentine channels*—which shows that Treviranus certainly did see the neurilemma, but misinterpreted what he saw.

Christian Gottfried Ehrenberg (6), of the *ganglion cells* in vertebrates and invertebrates: "In the ganglia of avian spinal nerves I have seen tubular nerves and very

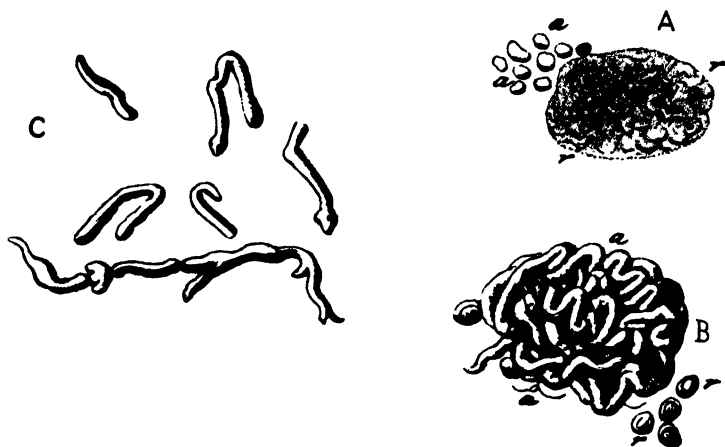


FIG. 7. FIGURE REPRESENTING THE WHITE BRAIN SUBSTANCE. (A) SHOWS A THIN PLANE OF THE WHITE BRAIN SUBSTANCE WHICH, WHEN SEEN THROUGH MICROSCOPE, SEEMS TO CONSIST OF A HEAP OF SMALL INTESTINES *r, r*. (B) SHOWS THE SMALL INTESTINES AGAIN, WHEN OBSERVED THROUGH A MUCH STRONGER MICROSCOPE, *a, a*, THE SMALL INTESTINES, *r, r*, THE LITTLE GLOBULES. (C) SHOWS MANY IRREGULAR CORPUSCLES WHICH, WITH A NEEDLE, WERE DETACHED FROM THE WHITE SUBSTANCE SHOWN IN FIG. B.

After Fontana (4), Plate V, Fig. 7, 9, 16.

He established that there were no encasing sheaths in the nerve fibers of the brain and spinal cord, and he was the first to introduce the term *Nervenmark* (myeline) by which, however, he denoted the contents of the tubes. His report contained the first correct drawing—here reproduced as Fig. 8—of a myelinated nerve fiber from the sciatic nerve of the live frog.

"Since 1833, when the use of the microscope grew fairly common, renewed activity developed in the investigations on the nervous system. Although it may be said that, with the number of established facts, there also cropped up an increasing number of errors, these errors were instructive and recent years show some of the discoveries to be of lasting value." [J. Henle (21), p. 777.]

The year 1833 brought the discovery, by

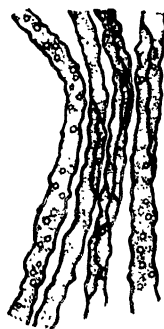


FIG. 8. LAST NERVE-TUBE FROM THE SCIATIC NERVE OF A FROG. According to Treviranus (5), Plate XIV, Fig. 75. [Reproduced after L. Stieda (32).]

large, almost globular (*kugelformige*), irregular bodies—some $\frac{1}{8}$ *Linien* in diameter—which formed the swellings proper and rather resemble some glandular substance" (6, p. 459). Ehrenberg was the first to

recognize in them structures of an individual character, and in a second report (7) described them as glandular globes (*drüsenartige Kugeln*), or club-like bodies (*keulenförmige Körper*). Of the true importance of his observations he had not the slightest notion. This may be in-



FIG. 9. HUMAN ARTICULATED BRAIN-TUBES. (A) SPINAL CORD SUBSTANCE, CONTAINING ARTICULATED TUBES OF EXTREMELY DIFFERING THICKNESS. (B) ARTICULATED BRAIN TUBES FROM THE OPTIC NERVE BEFORE THE CHIASMA. (C) ARTICULATED BRAIN TUBES FROM THE AUDITORY NERVE. After Ehrenberg (6), Plate VI, Fig. 3, 4, 6.

ferred both from the names he proposed and from the curious way in which he compared his *globes* with the *small lime bags* found in fishes and from the fact that, on recapitulating his first report, he does not so much as mention the nerve cells!

But Ehrenberg advanced another step in his study of the nerve fiber. He was one of the first to succeed in proving the existence of the central nerve fibers—he speaks of *articulate brain tubules* (*gegliederte Hirnröhren*)—and sharply distinguished them from the peripheral myelinated nerve fibers and what he called the *cylindrical simple nerve tubules* (*cyllindrisch einfache Nervenröhren*).

In justice to historical truth it must be said that the central nerve fibers had been previously observed and recognized as such by Purkinje who—as Valentin (8) declared in 1834—“had, for some years past, been demonstrating them in his physiological lectures.” Thus Valentin, when a student at Breslau in 1829 and 1830, had been shown these fibers (*Fäden*) by Purkinje.

According to Ehrenberg’s description the brain fibers are “not simple cylindrical fibers, but, on the contrary, might be compared with pearl strings whose beads are not in contact, or they resemble vitreous tubules having bubbles. They are always straight, mostly parallel, but some times intersecting” . . . “very rarely split into two, otherwise invariably hollow.” For this reason he called them intermittently swollen, i.e. varicose, articulate, tubules or channels [*“abwechselnd angeschwollene, das ist variköse, gegliederte Röhren oder Kanäle”* (6, p. 452)] (cf. Fig. 9).

An essential difference between the articulate brain tubules and the cylindrical, simple nerve tubules, i.e. between the central and peripheral nerve fibers, was found by Ehrenberg in that “the latter possessed a much larger inner cavity and therein encased very distinct, less transparent contents, which also had been recognized long ago” (6, p. 454).

Still further merit was acquired by Ehrenberg, when he showed beyond any doubt, the direct transition of the central into the peripheral, myelinated nerve fibers, and supplemented the proofs by a very good drawing (cf. Fig. 10).

According to his description, the nerves of the brain and the spinal cord, after emerging from the central organ, "gradually lose their varicose structure, the connecting parts of the globular or uniform joints grow thicker, and the whole finally takes on a cylindrical shape, of increasing regularity" (6, p. 459). He wrongly considered *none* but the peripheral nerve fiber to be myelinated; in his opinion, the same fiber in its central course "shows an entirely transparent, clear, marrowless, interior." Of the *Mark* (marrow, i.e. myeline) within the central

During the ensuing years hardly any attention was paid to Ehrenberg's first observation—entirely misconceived as to its importance—of the ganglion cells, which then usually were referred to as *Keulenkörper* (club-like bodies). The more violent the controversy around the question of the composition and importance of nerve fibers the more the principal interest of the discussion centered upon such problems as to how far these were to be considered artificial products, whether the nerve cylinders or nerve tubules were, in fact, hollow or solid structures, etc.

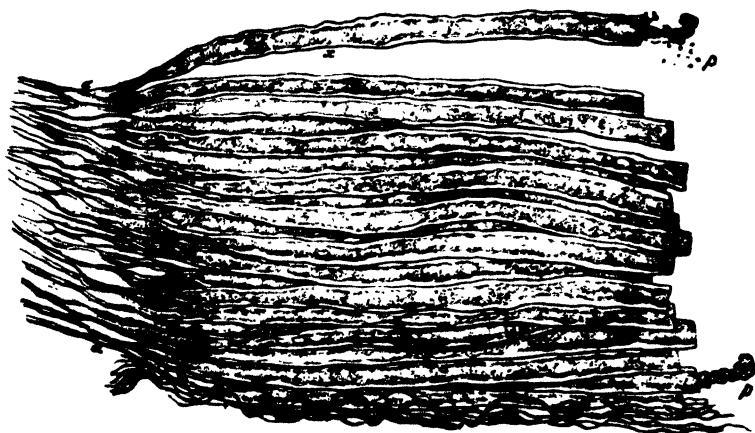


FIG. 10 A PIECE OF THE SCIATIC NERVE AT ITS ISSUE FROM THE SPINAL CORD. At α , the transition of the articulated tubes of the cord to the cylindric tubes of the sciatic. At ρ , nerve marrow emerging from the tubes
According to Ehrenberg (6), Fig. 11

nerve fibers he thought that it was a viscous, homogeneous juice.

This delusion, together with another erroneous assumption which led him to believe that, apart from the central organ and the optic nerve, the olfactory and acoustic and the "middle course of the sympathetic" contained central nerve fibers—explains why Ehrenberg incorrectly classified the nerve fibers as *marklose* (marrowless, i.e. amyelinated) varicose tubules (of the brain, spinal cord and the three higher sensory nerves), and cylinder-shaped *markhaltige* (marrowy, i.e. myelinated) tubules (of the peripheral nerves); to the sympathetic he ascribed both kinds of nerve fibers.

Among such investigators as succeeded in demonstrating the existence of the ganglion cells, thus elucidating the nature of nerve fibers, the following names may be mentioned, according to the years in which they published their respective reports: Valentin, Remak, Purkinje, Volkmann, and Johannes Müller.

It was G. Valentin (9) who—as asserted by Kölliker (29, p. 546) in his *Microscopical Anatomy* published in 1850—rendered the first good description of the

nerve elements. To him the myelinated nerve fibers, from their extreme periphery to their entrance into the grey substance, were like many conduit-pipes which, according to their location, were composed of a sheath made up of cellular tissue of varying thickness, and evenly clear, transparent, semi-liquid contents; inserted between the varicose (i.e. central) and the peripheral section there were particular "intermediate fibers."

Valentin showed the wide diffusion of the ganglion cells throughout the brain, the spinal cord, the spinal and sympathetic ganglia, and distinguished between their different forms.

Already Valentin mentions "globules rounded at one side" and "furnished with a tail-shaped end at the other," discovered by Purkinje in the cortex cerebelli and since known by the name of Purkinje.

The whole of them Valentin calls either nucleated globules (*kernhaltige Kugeln*) or globular masses (*Kugelmassen*), or overlay-globules (*Belegkörper*), also overlay-masses (*Belegungsmassen*); the two latter expressions referring to their position *between* the nerve tubules. Within the ganglion cells he described the nucleus and the nucleolus and their occasional pigmentation, and he stressed his observation of their each having "an exterior, more or less distinctly cellular, covering." The location of the ganglion cells, as established by Valentin,—any connection between nerve cells and nerve fibers was entirely unknown at that time—also explains such expressions as were used by him—globules of the peripheral interstitial overlay-formation (*Kugeln der peripherischen interstitiellen Belegungsformation*) and globules of the pure, continuous overlay-formation (*Kugeln der reinen, kontinuierlichen Belegungsformation*)—to denote peripheral and central ganglion cells, respectively.

From the purely accidental fact that the first of those globules (*Kugeln*) were observed within ganglia, there originated the term ganglion or ganglionic globules (*Ganglienkugeln*), which I find to have been used for the first time in the *Jahresbericht über die Fortschritte der anatomisch-physiologischen Wissenschaften im Jahre 1836* (Müllers Arch. f. Anat. Physiologie u. wissenschaft. Med., Jahrg. 1837). Somewhat later, there appears the standard expression ganglion cell (*Ganglienzelle*)—now still used—and which, to quote an instance, is employed by A. Hannover (19, p. 556) to distinguish between this cell and the brain cell (*Hirnzelle*).

Robert Remak, who wrote a number of neuro-histological works, in his first publication (10) in 1836 described and illustrated those strictures which afterwards by the name of "Lanternman's Incisors" were to find their way into the literature of the subject.

Particular mention must be made here of this publication (10) on account of its being the first to deal with the *development of nerve fibers*. According to Remak's report the myeline-sheathed fibers contained no medulla at first, and passed into cylindrical form through the intermediate stage of transitional fibers. He had noticed moreover that the formation of myeline in the nerves of young pigeons advanced at a quicker rate of progress than in rabbits of corresponding age.

In his next publication Remak (11) reported on the discovery of the *axis cylinder*. While many of the earlier authors, as Ehrenberg for instance, had considered the primitive fibers or primitive tubes to be hollow structures, and Purkinje had his doubts about this view, Remak found in these cylinders a smooth, glossy filament, often protruding from the interior of the tube, which was of tougher texture than the sheath, and which he called the

primitive band (*Primitivband*). On being variously magnified and illuminated, this primitive band very often "impressed him as being composed of very minute, solid fibers, which, in their course, sometimes swelled out into small nodules." For this reason Remak believed, not incorrectly, that "the primitive band one day would prove to be a primitive bundle."

Remak (25, p. 197) in an essay—published in 1843—on the nerves found in the ventral cord of *Astacus fluviatilis*, calls the axis cylinder the central bundle of nerve fibers (*das centrale Nervenfaserbündel*), because "it is composed of extremely tender fibers, which, within the tube, occupy a fourth to a third part of its diameter."

In 1837, Johann Evangelista Purkinje (13) stated in his "Latest researches into the anatomy of the nerves and the brain"—a paper read at the Naturalists' Congress held in Prague—that in a "very minute, transparent cross-section of the nerve-bundles of a freshly removed nerve . . . there appeared at the extreme periphery a circular double-contour, corresponding to the encasing membrane of the nerve cylinder, which, like a vessel, contains the myeline; thereupon follows towards the center a thicker circle, the stratum of the myeline, and in the center a multi-cornered, entirely transparent spot, which might be regarded as the interior channel of the myeline" (p. 177). (Cf. Fig. 11.)

"On inspection of a thin longitudinal section of the hardened nerve, the center of the medulla displayed a minute, transparent streak. A similar phenomenon was observed in the cylindrical fibers, when they were squeezed from out of their hose-like elementary filament" (p. 177 to 178). Purkinje thought that "those observations pointed to some organically planned structure within the medulla of the elementary nerve cylinder, and that it was difficult to believe of such structural

relations that they should have been caused alone by the effect of the hardening agents" (p. 178).

The expression *cylinder axis* (Latin: *cylinder axis*; German: *Achscylinder*), meant to denote the central fiber which was discovered by Remak—although also observed nearly simultaneously by Purkinje—appeared for the first time in the dissertation "De formatione granulosa in nervis aliisque partibus organismi animalis" published in 1839 by J. F. Rosenthal [17, p. 16—quoted from J. Henle (21, p. 782)], a pupil of Purkinje's. It seems that Rosenthal was also the first to use the term *myeline sheath* (*vagina medullaris*, *Markscheide*).

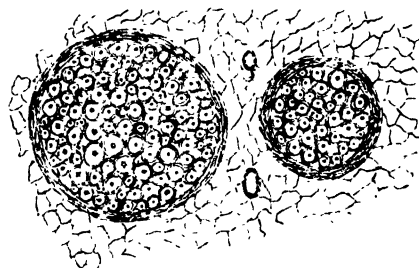


FIG. 11. TRANSVERSE SECTION OF A HARDENED NERVE After Purkinje (13; Fig. 9).

Concerning the ganglion cells, Purkinje had, as early as 1831, conceived a fairly adequate notion of the structure of nerve cells. In that year, on observing the so-called substantia nigra (cf. Fig. 12, A), he detected "dark-brown spots (*Flocken*), even fairly visible to the unaided eye," and he realized at once their complete analogy to those ganglionic granules, afterwards discovered by Ehrenberg. Purkinje then studied ganglion cells from widely different parts of the central organ: e.g., of the cerebral and cerebellar cortex (cf. Fig. 12 B), of the corpus geniculatum, cornu ammonis, optic thalamus, substantia nigra, the pons and the olivae. He summarized the essential characteris-

tics of the ganglion cell—which he usually denoted as ganglionic corpuscles (*Gangliöse Körperchen*)—in a manner which, judged by the standards of his age, was nothing short of remarkable: "A granular, partly globular, partly round-edged shape, with or without one or more processes; their substance is fairly hard, transparent, consisting of a mass of free, probably nervous, points, and to the pressure of chemical reagents offers more en-

cellular or even fibroid covers, out of which it is impossible to remove them otherwise than by the strongest pressure; covers of this kind are not observed in the ganglionic corpuscles of the brain; in many ganglionic granules of the cerebral and the nervous system there are found pigmented spots. . . ." (p. 179).

As to the meaning of the ganglion cells, Purkinje stated that "they probably were central structures, which was suggested



FIG. 12. (A) MULTIPOLAR GANGLION CELLS FROM SUBSTANTIA NIGRA, SHOWING PIGMENT (B) FIRST DRAWING REPRESENTING THE PURKINJE CELLS IN THE CEREBELLUM According to Purkinje (13), Fig. 16 and 17

during resistance than any other nerve substance; the ganglion cell, which measures from $\frac{8-30}{800}$ of a Viennese 'Linie', must be called large, if compared with other microscopic structures. Within, it contains a round, slightly pellucid nucleus, which again is encased in a larger spherical covering, and in size is proportionate to the size of the ganglionic granule as a whole; such granules as are situated within the nerve ganglia possess individual

by the whole of their thrice concentric organization, and the relation they might bear to the elementary cerebral and nerve fibers probably resembled that between force-centers and conducting-lines, or ganglia and ganglionic nerves, or cerebral masses with spinal nerves and the brain. They might be collectors, generators, and distributors of the nervous organ" (p. 180).

Apart from these considerations, Purkinje had already considered the ques-

tion "of the relation between the ganglionic corpuscles and the elementary fibers of the nerves and brain," of which, however, "it had been found impossible so far," according to his statement, "to ascertain anything of a definite character" (p. 179).

Meanwhile, in 1837, Remak (12) had inserted the last link in the chain of such discoveries as were made previously to the appearance of Schwann's treatise. He succeeded in proving that the grey color, observed in the sympathetic cord, was not caused "by the ganglionic globules there scattered, but by fibers themselves." These, accordingly, differed from the already known white nerve fibers by their peculiar structure and, in Remak's opinion, originated within the sympathetic ganglion cells. In subsequent remarks (14, 15) he spoke of them as the *grey fibers*, or *organic nerve fibers*. They have ever since been known by his name: *Remak fibers*.

Publication No. 15 is merely an extract from Remak's extensive and well-known dissertation "Observationes anatomicae et microscopicae de systematis nervosi structura" of 1838, a copy of which has been at my disposal in the original and from which Fig. 13 is reproduced. The other publications of Remak (Nos. 11, 12 and 15 of the bibliography) had to be cited according to the sources mentioned.

With Remak (14, p. 5) the passage in question runs: [It should be borne in mind that the fibers of the grey cords] "are not tubular, i.e. surrounded with a sheath, but naked, being transparent, almost gelatinous, and much more minute than most of the primitive tubes. They almost always exhibit longitudinal lines upon their surface and readily separate into very minute fibers. In their course they are very frequently furnished with oval nodules and covered with certain small oval or round, more rarely irregular, corpuscles, which exhibit one or more

nuclei, in size almost equal to the nuclei of the ganglion globules." This passage, together with the drawing supplementing it (cf. Fig. 13), clearly shows that Remak was quite an acute observer of the nerve fibers he discovered.

But, in my opinion, particular importance ought to be ascribed to the fact that Remak realized how the organic nerve fibers originate from the ganglionic globules of the sympathetic ganglia (cf. Fig. 13)—while he saw a peculiar difference "between the sympathetic and the spinal ganglia in that within the spinal ganglia the fibers pass between the ganglionic globules, or weave their fabric around the latter." To continue in his own words: "The organic fibers (of the *sympathetic* ganglia) originate from the substance of the nucleated globules. They are visible as cords of varying strength, sometimes resembling the primitive tubes, very transparent, but differing inasmuch as they are composed of the *most minute, non-tubular* fibers; or there issue forth from several points of the globes the *most minute* fibers, which, right from their origin are knotty, and *quite distinctly pass into organic fibers*."

We might still mention that Volkmann (16), when studying frog ganglia, came across those globules, discovered by Ehrenberg; but he doubted whether the "extremely regular, almost quite globular, rarely oval" structures represented any part of the nervous tissue at all.

IV

In rough outline we have here sketched the stage of development of neuro-histological research as it was at the time of the publication of Schwann's work which was to make his name forever famous.

Lack of space prevents quotation from works from authors who failed to reach results of a general nature. But it would

be wrong to imagine the previous development as having proceeded along more or less straightforward lines. On the contrary, each one of the fundamental discoveries gave rise to disputes which we need not enter into here. For instance, Arneemann, in 1787—as related by Stieda (32, p. 11)—declared Fontana's discovery to be an "optical illusion." Even at and

nated nerve fibers in the peripheral and central nervous system, of the grey fibers and the ganglion cells, the principal elements of which the nerve texture is composed had become known. But the architectural organization of the structure into which these elements enter remained shrouded in darkness as it had been before.

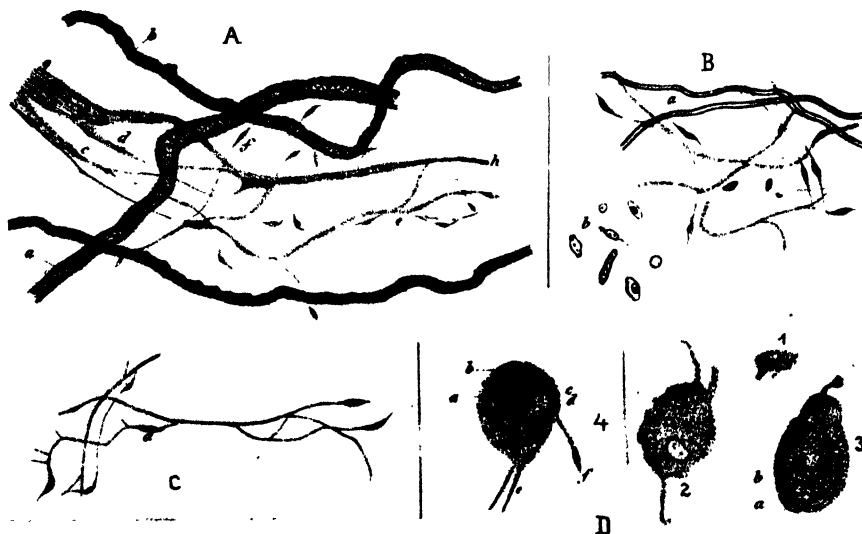


FIG. 13. (A, B) NERVE FIBERS FROM THE BOVINE SYMPATHETIC (200 \times MAGNIFIED). (A) *a, b*, AND (B) *a*, PRIMITIVE TUBES. (A) *c-h*, ORGANIC NERVE FIBERS, AT (B) *b*, SOME NUCLEATED CORPUSCLES ISOLATED FROM THE COURSE OF THE ORGANIC FIBERS. (C) ORGANIC NERVE FIBERS FROM THE HUMAN SYMPATHETIC (150 \times MAGNIFIED), AT *a*, ONE NUCLEATED CORPUSCLE. (D) GANGLIONIC GLOBULES FROM A BOVINE SYMPATHETIC GANGLION WITH ORIGINATING ORGANIC NERVE FIBERS, AT 3, ONE BINUCLEATED GANGLION CELL (1 = 75 \times MAGNIFIED, 2 AND 3 = 200 \times MAGNIFIED, 4 = 150 \times MAGNIFIED)
According to Remak (14), Fig. 2, 3, 4, 7, 9

after Schwann's time, nearly all the histological observations here referred to met with much opposition, a fact that only serves to add to our esteem for Schwann's achievement. No mention has been made of some theories which today appear very odd: e.g., Ehrenberg maintained that the peripheral nerve fibers were motor and regarded the central ones as nerves of sensation.

Thanks to the discovery of the *myeli-*

The merit of Theodor Schwann consists in his having been able to prove the *cellular nature* of the ganglion globules. The former names, as e.g., club-like bodies (*Keulenkörper*) or overlay-globules (*Belegungskugeln*), given to them by Ehrenberg and Valentin, respectively, are sufficient to prove that no one had the slightest notion of their true nature.

Schwann's accomplishment was to form the permanent foundation on which the

impressive edifice of neuro-histological science could be erected. Founded on that base are also the further discoveries of which I shall point out the most important: the real relation existing between nerve cell and nerve fiber (cf. Fig. 14). A connection between ganglion cell and nerve fiber had been first asserted by Remak for the sympathetic nervous system, and as early as 1840 described by Hannover (19); in 1842 it was definitely proved for invertebrates—mostly on the brain ganglia of *Hirudo vulgaris*—by Helmholtz (22), and in 1844 for vertebrates by Kölliker (26).

It is odd, indeed, that in 1841 J. Henle (21) and, even as late as 1850, A. Kölliker (29) should declare themselves to have been unsuccessful in their endeavor to observe these nuclei. Also Bidder (27) in his celebrated treatise *Zur Lehre von dem Verhältniss der Ganglienkörper zu den Nervenfasern* (cf. Fig. 14), does not so much as mention the cells of Schwann. Bidder obviously failed to notice the nuclei of Schwann, although in the bipolar ganglion cells from the cerebral ganglia of *Esox lucius* he had an excellent object (cf. Fig. 14) for observation—by means of which, on the other hand, he found sure and convincing proof of the direct transition of the neurilemma from nerve fiber to ganglion cell.

As far as I have been able to ascertain, E. Reissner (30) was the first (1861) to form a correct notion of the regular occur-

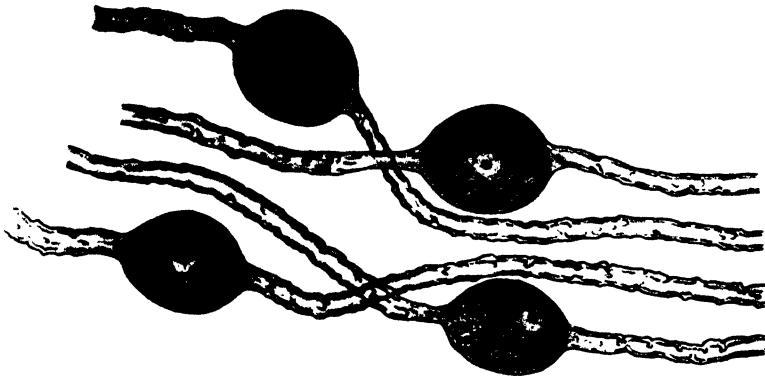


FIG. 14. GANGLIONIC GLOBULES INSERTED INTO ENLARGED PARTS OF WIDE PRIMITIVE TUBES. From the trigeminus of *Esox lucius*. Immediate transition of the "primitive sheath" from nerve fibers to the ganglion cell. According to Bidder (27), Plate I. [Detail from Bidder, Fig. 1.]

The existence, within the nerve fibers, of the *cells of Schwann*, was soon confirmed by numerous authors; the first among these were J. F. Rosenthal [17, p. 18, cited from J. Henle (21), p. 620] and Johann N. Czermak (28), both of whom had been disciples of Purkinje, G. Valentin (20), R. Remak (25), and E. Reissner (30).

Valentin's confirmation of Schwann's discovery concerns the development of the nerve fiber where he had observed the plentiful occurrence of the nuclei. Further remarks on this point will be found in my forthcoming monograph.

rence of the Schwann cells: he showed how to stain with carmine their spindle-shaped or elongated nuclei after having hardened the nerve in chromic acid. He found that these nuclei were rather sparsely diffused throughout the thick fibers, while more plentiful in the minute ones (cf. Fig. 15), "but they were always present in any piece of an isolated nerve above a certain length" (p. 730). That is why Reissner "from numerous observations on the nerves of man and of some vertebrates" draws the correct conclusion that the

nuclei, which had been "previously observed in the primitive sheaths of nerve fibers by Schwann" would have to be "considered to represent a universal characteristic of the nerve fibers in general." "By proving the regular occurrence of nuclei within the primitive sheaths of



FIG. 15. ISOLATED NERVE FIBERS FROM THE HUMAN OCULOMOTORIUS. *a, a*, MINUTE NERVE FIBERS WITH NUMEROUS NUCLEI; *b*, ONE NUCLEUS PARTLY DETACHED FROM THE NEURILEMMA
After Reissner (30), Plate XVII, Fig. 5

nerve fibers, the correspondence with the sarcolemma of the cross-striated muscle fibers becomes complete" (p. 731).

Theodor Schwann's contribution to the development of neuro-histology consists of:

(*a*) *his realization of the cellular character of the ganglion cells;*

(*b*) *his discovery of the cells since known by his name—although, in justice to historical truth, it must be mentioned that prior to him Robert Remak had seen analogous nuclei in those grey or organic fibers of which he gave the first description;*

(*c*) *the establishment of the so-called cell-chain theory in the development of the peripheral nerve fibers.*

This paper—occasioned by the centenary of Schwann's famous treatise—represents an extract from the introductory chapter of a monograph on the *Cell of Schwann*, the publication of which has been delayed. We now usually refer to the sheath cells of Schwann or sheath cells, which is in accordance with the German expression *Zellen der Schwannschen Scheide*. But I doubt if by this term *sheath* the function of the cell could be adequately, much less exhaustively, characterized—a fact that I (34) hinted at years ago, and that I am going to revert to more fully in the forthcoming publication. But even so, at this juncture, I prefer the less committing term *cell of Schwann*. This proposition perhaps will appear the more justified, because it then would not give rise to misunderstanding—the name of Schwann being commonly used only with this *particular* kind of cell.

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HOMING INSTINCT IN SALMON

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The Scripps Institution of Oceanography (Contribution No. 73)

KNOWLEDGE of the migrations of fishes is of considerable economic importance and biological interest. Most fisheries depend on the congregation of certain species for feeding or spawning in definite regions; a knowledge of the movements of the fishes to and from these regions has aided the prosecution of the fishing operations and has been of value in attempts at regulation of these operations with a view to conservation. Russell (1937) states that most fish migrations consist (1) of a dispersal of eggs, larvae, or young fishes by passive drifting with the current or by active seeking of the normal habitat, then (2) of an active movement, usually against the current, to the spawning grounds, and finally (3) of a dispersal of the spent fishes, either by movement with a current or an active feeding migration.

Salmon migrations are in general accord with this plan. The young fishes go down-stream to the sea after a stay in fresh water which varies in length with the species and with conditions in the stream. There follows a period of feeding and growth in the sea which also varies in length, but rarely, if ever, exceeds five or six years. The mature fishes now enter streams and proceed to spawning grounds; after spawning, the Pacific species of salmon die, while the steelhead trout and the Atlantic salmon may return to the sea, subsequently to enter a stream and spawn again.

The suggestion was made many years ago that the salmon invariably returns for spawning to the stream in which it was hatched. Many biologists looked upon this view with skepticism. Jordan (1925) opposed the idea, and Rutter (1903) said,

"It is incredible that the salmon remember their native stream during two or three years of ocean life and that they consciously seek it when they desire to return to fresh water. Probably most of them do return to the stream from which they entered the ocean, not because it is their native stream, but because they do not get very far from its mouth, and when ready to return to fresh water, it is the first to attract them."

This belief has been maintained up to the present time by certain workers (Huntsman, 1937a,b, 1938a,b,c,d, 1939; Ward, 1939a,b). Others, however, have become convinced that salmon may go considerable distances in the sea, and yet return in a great majority of cases to their parent stream (Calderwood, 1908, 1931, 1937; Clemens, Foerster, and Pritchard, 1939; Davidson, 1937; Menzies, 1938b; Pacific Fisherman, 1937; Rich, 1937a,b, 1939; Shapovalov, 1939). This paper is an attempt at an impartial evaluation of such information bearing on the question of "homing" as is available in the literature.

There are several common names in use for the seven species of salmon and trout on which the studies reported here were made. Specific names, to avoid confusion, will be used here. The corre-

sponding common names are given in the table.

METHODS

In large part, data on salmon migrations have been accumulated by means of marking and tagging experiments. Young fishes have been marked by the removal of one or more fins; adult fishes have been tagged by affixing a numbered tag of metal or other material to the caudal fin. The only errors inherent in the tagging method appear to be the possibility of loss of the tag, or of an increased mortality of tagged fishes. This method cannot be applied to young fishes, however, so that

noted by other workers, and it is now the belief of most that to obtain valid results in fin-marking, it is necessary to remove two fins, one from each of two regions—as, for example, the adipose fin and one of the ventrals. It has also been found that the fin rays must be removed completely in order to preclude the possibility of regeneration. These matters are discussed by Rich and Holmes (1928) and by Pritchard (1937).

Two general types of experiment have been performed. Young fishes have been marked in streams at the time of liberation from a hatchery or at the time of the down-stream migration. These fishes

TABLE 1
Common names of salmon and trout

| GENUS | SPECIES | COMMON NAME |
|---------------------|--------------------|--|
| <i>Oncorhynchus</i> | sp. | Pacific salmon |
| | <i>gorbuscha</i> | Humpback or pink salmon |
| | <i>keta</i> | Chum or dog salmon |
| | <i>kisutch</i> | Coho or silver salmon |
| | <i>nerka</i> | Blueback, quinnault, red, or sockeye salmon |
| | <i>tshawytscha</i> | Chinook, king, quinnat, spring, or tyee salmon |
| <i>Salmo</i> | <i>gairdnerii</i> | Steelhead trout |
| | <i>salar</i> | Atlantic salmon |

most experiments on Pacific salmon have involved fin mutilation. It has frequently been demonstrated that removal of a single fin or even of two members of the same pair of fins does not give reliable results. Marsh and Cobb (1911) reported results from 1600 specimens of *O. nerka* marked in the Naha River, Alaska, by removal of both ventral fins. Nearly half of the recoveries were made in another river, so the search was continued for several years. Finally, Cobb (1917) concluded "... This experiment proves ... that the percentage of salmon which accidentally lose ... one or more fins is much larger than most people suppose." Similar experiences have been

have subsequently been recovered in this same stream, at sea, or occasionally in other streams. Adult fishes have been tagged in the sea, and recovered later elsewhere at sea or in streams. In addition, profiting from the fact that *S. salar* makes several spawning migrations, Atlantic Coast workers have tagged adult specimens in streams after spawning (kelts). In interpreting results from marking and tagging experiments, it must be remembered that results will depend on several factors other than the actual number of fishes in a given area. Of first importance is the intensity of fishing operations in the area. In second place, is the possibility that marked or tagged

fishes may not be observed or reported. In general, rewards are offered for the recovery of such fishes, and in many cases, trained observers are stationed at canneries, counting wiers, and other places where large numbers of fishes are easily seen.

THE MARKING OF SALMON IN STREAMS

The results of all of the experiments which the writer has been able to discover in the literature in which salmon have been marked or tagged in streams are summarized in Table 2. Certain experiments in this group can at once be eliminated as invalid. Thus, experiments 6 and 25 involved the removal of the adipose fin only; this mark is very often duplicated in nature. Experiments 15, 17, 18, 26, and 28 involved the removal of both pectoral or both ventral (pelvic) fins: Cobb (1917) has shown that this mark may also lead to erroneous results. Cf the experiments remaining, we must use great care in evaluating those reported by Huntsman (1938a: expts. 7-13) since the tags were affixed to fishes caught in the estuaries of the various streams, with the exception of the Annapolis (expt. 8). It is known that mature fishes may enter the estuaries of rivers, leave these estuaries without proceeding up the rivers, and later enter other rivers to spawn. Taft and Shapovalov (1938) report an experience with *S. gairdnerii* in two small California creeks. The fish in question was marked by removal of adipose and left ventral fins at the hatchery, two miles upstream from the mouth of Scott Creek, in February, 1935. In February of 1937, it appeared at a counting wier situated a mile from the mouth of Waddell Creek, a stream which enters the Pacific Ocean five miles north of the mouth of Scott Creek. The fish was taken from the water, further marked by removal of half of the dorsal fin, and scales and

measurements taken; it was then replaced in the stream. Five days later, the same fish, easily recognizable and still unspawned, was found at the Scott Creek hatchery. An experience with *O. tshawytscha* in the Columbia River is also of interest here (Higgins, 1937). Over 1,000 adult fishes from the fall spawning run in the Columbia were tagged at a point nearly five miles up the river (i.e. in the estuary); five of these were soon afterwards taken in the sea outside the river, and one entered a small river several miles north of the Columbia. It cannot then be stated with any degree of positiveness that all fishes to be found in the estuaries or near the mouths of rivers would normally spawn in those same rivers.

Bearing these considerations in mind, we may now turn to Table 2. The accuracy of the homing of *O. nerka* to the Fraser River is beyond question. (Clemens, Foerster, and Pritchard, 1939: expt. 19) when it is considered that nearly 2500 fishes were recovered in Cultus Lake, where they had been marked, and that none appeared in any other river system than the Fraser. Furthermore, the other 8400 recoveries were all made in areas which would conceivably be en route from the sea to the Fraser, at the time of the normal spawning run through these areas. Impressive likewise are the results of Snyder (1931: expt. 21) in the Klamath with *O. tshawytscha*, and of Rich and Homes (1928: expt. 20) with the same species in the Columbia. These and the other experiments leave but little doubt that in many cases the return to the stream of liberation is overwhelming.

There are, however, a few cases, other than those which might be ascribed to faulty marking, in which a notable amount of straying has taken place. Taft and Shapovalov (1938: expt. 29) report that 35 specimens of *O. kisutch*

TABLE 2.—Experiments in which salmon or trout were marked or tagged in streams

| EXPT. NO. | GENUS | SPECIES | AUTHOR | DATE | RIVER | REGION | MARK USED | NUMBER MARKED | NUMBER RECOVERED IN | | | |
|-----------|---------------------|--------------------|--------------------------------|---------|--------------------|---------------|---------------------------|---------------|----------------------|------------------|------------------|---------------|
| | | | | | | | | | Stream of liberation | General vicinity | Neighbors at sea | Other streams |
| 1 | <i>Salmo</i> | <i>salar</i> | Calderwood | 1903-8 | Deveron | Scotland | Tag | — | 4 | 5 | 7 | 0 |
| 2 | " | " | " | " | Helmsdale | " | " | — | 24 | 1 | 7 | 1 |
| 3 | " | " | " | " | Naver | " | " | — | 16 | 1 | 1 | 0 |
| 4 | " | " | " | " | Tay | " | " | — | 49 | 1 | 0 | 0 |
| 5 | " | " | Alm | 1931 | Indals & Angermann | Sweden | " | 6,325 | 12 | 0 | 10 | 0 |
| 6 | " | " | White | 1936 | Apple | Nova Scotia | Ad | 3,252 | 92 | 0 | 0 | 6 |
| 7 | " | " | Huntsman | 1938 | Apple | " | Tag | 235 | 17 | 1 | 1 | 0 |
| 8 | " | " | Rodd | 1934-38 | Annapolis | " | " | 734 | 17 | 2 | 10 | 0 |
| 9 | " | " | " | " | Margaree | " | " | 3,534 | 25 | 67 | 13 | 1 |
| 10 | " | " | " | " | Miramichi | New Brunswick | " | 2,104 | 23 | 0 | 2 | 0 |
| 11 | " | " | " | " | Restigouche | " | " | 1,990 | 16 | 0 | 1 | 1 |
| 12 | " | " | " | " | Sackville | " | " | 398 | 19 | 0 | 4 | 0 |
| 13 | " | " | " | " | St. John | Nova Scotia | " | 2,021 | 35 | 2 | 0 | 0 |
| 14 | " | <i>gairdnerii</i> | Taft & Shapovalov | 1938 | Waddell | New Brunswick | Ad V | 4,479 | 203 | 0 | 0 | 2 |
| 15 | " | " | " | " | " | California | P P | 3,128 | 27 | 0 | 0 | 3 |
| 16 | " | " | " | " | Scott | " | Ad V | 17,683 | 432 | 0 | 0 | 6 |
| 17 | " | " | " | " | " | " | V V | 16,713 | 127 | 0 | 0 | 1 |
| 18 | <i>Oncorhynchus</i> | <i>nerka</i> | Marsh & Cobb | 1911 | Naha | Alaska | V V | 1,600 | 21 | 0 | 0 | 19 |
| 19 | " | " | Clemens, Foerster, & Pritchard | 1939 | Fraser | Br. Columbia | Ad PP | 469,326 | 2,495,840 | 0 | 0 | 0 |
| 20 | " | <i>tshawytscha</i> | Rich & Holmes | 1928 | Columbia | Oregon-Wash. | {Ad V Ad D} {DV Ad VV} | 334,000 | 498 | 3 | 1 | 0 |
| 21 | " | " | Snyder | 1931 | Klamath | California | Ad V | 122,000 | 1,171 | 32 | 150 | 0 |
| 22 | " | " | " | " | Sacramento | " | Ad V | 48,400 | 12 | 4 | 0 | 0 |
| 23 | " | <i>gorbuscha</i> | Davidson | 1934 | Duckabush | Washington | Ad D | 36,000 | 8 | 0 | 0 | 2 |
| 24 | " | " | " | " | Snake | Alaska | Ad D | 50,000 | 23 | 0 | 0 | 0 |
| 25 | " | " | Pritchard | 1939 | McClinton | Br. Columbia | Ad | 185,557 | 96 | 36 | 52 | 0 |
| 26 | " | " | " | " | " | " | VV | 107,949 | 2,941 | 325 | 10 | 0 |
| 27 | " | " | " | " | " | " | Ad VV | 85,634 | 35 | 0 | 0 | 0 |
| 28 | " | " | " | " | " | " | Ad V | 108,200 | 4 | 0 | 34 | 6 |
| 29 | " | " | " | " | Fraser | " | VV | 8,741 | 5 | 51 | 2 | 6 |
| 30 | " | <i>kisumb</i> | Taft & Shapovalov | 1938 | Waddell | California | Ad V | 6,683 | 140 | 0 | 1 | 35 |

Note: The term "general vicinity" applies to the area in the sea along the coastline between the stream in which the marking was done and the next stream of comparable size. Abbreviations: Ad = adipose fin, V = ventral fin, P = pectoral fin, D = dorsal fin.

strayed from Waddell Creek, where they were marked, to Scott Creek, five miles away. In the same period, 140 fishes from the same marking appeared in Waddell Creek. In this experiment, every fish passing up both streams was examined. The fishes marked were from naturally spawned eggs. Another case of straying is shown in expt. 28 (Pritchard 1938, 1939) where six specimens of *O. gorbuscha* reared and marked at McClinton Creek (in the Queen Charlotte Islands area, B.C.) from eggs from the nearby Tlell River, were found in the Fraser River, over 500 miles to the south and east. Thirty-four other specimens from this marking were found in the Gulf of Georgia, near the mouth of the Fraser, and only four entered McClinton Creek. It should be noted that all fishes entering McClinton Creek were examined. Experiments 2, 9, 11, 14, 16, and 23 also record a very small amount of straying for *Salmo* species and for *O. gorbuscha*. The fishes of expts. 9 and 11 entered streams at considerable distances—over 200 miles—from the stream of tagging, but it must be remembered that they were tagged in estuaries, and might never normally have spawned in the river where the tagging was done. The fish of expt. 2 entered a river about 100 miles from the river in which it was tagged. No details were given as to the part of the river in which the tagging was done.

There are then four experiments in which fishes marked in a particular stream are known to have entered another at a distance of 100 miles or more away (2, 9, 11, 28). On the other hand, in the various experiments of Taft and Shapovalov (1938: expts. 14, 16, 30) the straying was from one stream to another of comparable size and situation separated from the first by only five miles of open coast line. And in Davidson's (1934) experi-

ment (23) the fishes marked in the Duckabush River strayed into two streams similar in size, one eight miles away and the other four miles, along the same shore of a narrow channel. All of the streams in this area were observed from time to time during the period of the experiment. A preliminary report of an experiment not listed in the table (Higgins, 1938) should also be noted here. Incomplete results on marking experiments on *O. nerka* conducted on the Karluk River and the Red River, Alaska, show that 5 per cent of recoveries of fishes marked in the Karluk are made in the Red River, and 0.6 per cent of the Red River fishes stray to the Karluk. Both streams are watched continuously; they are about 35 miles apart, on Kodiak Island.

Ward (1939a, b) has contended that marking experiments of this sort are of no value because of the small number of returns. A very large number of such experiments have now been performed, however, and, as we have seen, in virtually every case the results have been the same—namely, that the great majority of the fishes recovered in streams are found in the same streams which they left as young fishes. In view of this virtual unanimity, Ward's contention loses its force. We may then conclude that the majority of salmon reared and liberated in, or for *Salmo* species spawning in, a given stream will return for spawning to that same stream. We may also conclude provisionally that a limited and undetermined amount of straying to other streams will occur in certain cases. In most cases, this straying, when it has been observed to occur, has been only to streams near the stream of liberation.

Several attempts have been made to study the return of salmon to particular tributaries within a large river system.

These experiments are reported by Rich and Holmes (1928), Snyder (1931), Taft and Shapovalov (1938), and Clemens, Foerster, and Pritchard (1939). We will first consider experiments in which the marked fishes were hatched, reared, and liberated in the same stream from eggs spawned in that stream. These include two experiments of Rich and Holmes on *O. tshawytscha* in the Little White Salmon River, and one in Spring Creek, both tributaries of the Columbia entering the main stream approximately 150 miles from its mouth. In these experiments, altogether, 174,000 fishes were marked. Most of the recoveries were made in the sea or in the main Columbia River en route to the spawning grounds, but 99 fishes of the marked group succeeded in reaching the tributary of liberation, while three entered streams one to five miles up the river, and two entered streams five to fifteen miles down the river from that tributary. Snyder marked altogether 50,000 specimens of *O. tshawytscha* in Fall Creek on the Klamath River, California; 34 reached Fall Creek on the return migration, while three entered a stream seven miles below Fall Creek. Taft and Shapovalov marked *S. gairdnerii* in Fall Creek and found that 45 returned to that tributary, while none were recovered in any other; on the other hand, from a marking experiment in Beaver Creek, another tributary of the Klamath, three fishes appeared in streams 20 to 40 miles farther up the river, while 70 entered Beaver Creek. The results cited in expt. 19, Table 2, should again be noted here. According to the report of Clemens, Foerster, and Pritchard (1939), the entire run of *O. nerka* from Cultus Lake, a tributary of the Fraser River, was marked; 2500 marked fishes returned to the lake, and none was found in any other tributary of the Fraser, although a fairly careful

watch was kept. In addition, few unmarked fishes appeared in Cultus Lake, indicating a very small infiltration from other areas.

A second type of experiment involves the marking of fishes reared and liberated in the same stream, but from eggs spawned in another tributary or even in another river system. Several experiments were performed by Rich and Holmes (1928) at Bonneville Hatchery, about 100 miles up the Columbia River. Eggs obtained from various tributaries of the Willamette River, a large tributary of the Columbia entering the latter about 75 miles from the sea, were used in these experiments. A total of 280,000 yearlings of *O. tshawytscha* were marked; only 6 returned to the hatchery where they were liberated, and 374 were taken in the main river, 105 of these above the hatchery. To this might be added a similar experiment with fishes from Willamette eggs reared and liberated in Herman Creek, near Bonneville. In this case only 20,000 were marked, and two returned to Herman Creek, while 46 were taken in the main river, six of these above Herman Creek. It should be noted that the tributaries from which the eggs came were in general at a greater distance from the sea than those in which the fishes were liberated; it should also be noted that, though reasonable watch was kept, none of these fishes was observed to enter the Willamette River. Snyder took eggs of *O. tshawytscha* from Mill Creek, a tributary of the Sacramento River somewhat over 150 miles from the sea, and reared the fishes in the Mt. Shasta hatchery, near the headwaters of the Sacramento. These fishes, numbering 15,400 were marked and liberated at the hatchery, in Sullaway Creek. None of the fishes ever reached Sullaway Creek again, but six entered Mill Creek, and fifteen appeared in Battle

Creek, several miles up the river from Mill Creek. There is a very brief report of a marking experiment of this type involving *O. nerka* (Higgins, 1933). Eggs from the Baker River, a tributary of the Skagit River, Washington, were transferred to Grandy Creek, farther up the Skagit; 48,000 young fishes from these eggs were marked. The entire runs of both Grandy Creek and the Baker River were watched, and marked fishes were observed to appear only in Grandy Creek. This report should be compared with the statements of Ward (1939), who claims that the lower temperature of the Baker River causes the entire run of *O. nerka* to be diverted into that tributary, and who states that in consequence planting experiments in tributaries above the Baker have failed.

Finally, another experiment of Snyder's is of interest. Using *O. tshawytscha*, he liberated yearlings (i.e. fishes ready for migration) which had been raised in Fall Creek (Klamath River) from Fall Creek eggs in the Shasta River near its mouth and in Jenny Creek. Both of these streams are tributary to the Klamath; the Shasta River is a relatively large stream, entering the Klamath about 180 miles from the sea, and Jenny Creek is smaller, opening about two miles below Fall Creek and fourteen miles above the Shasta. In each of two successive years, 25,000 fishes were liberated in each stream. Four of the Shasta fishes entered that river, and none was noted at other points. At Klamathon Racks, above the Shasta, where all fishes passing up the Klamath are normally trapped and may be examined, 137 of the Jenny Creek fishes appeared. Of these 85 were permitted to pass up the river; only one appeared in Jenny Creek, while 16 went to Fall Creek, and one to another nearby stream just below Jenny Creek.

Taking these experiments with the

others, we may conclude that when eggs spawned in a particular area—the nature and size of which for any particular case is as yet undetermined—are hatched and the young fishes reared in that same area, the majority of these fishes will return to the area to spawn. The accuracy of this return probably varies with species, with locality, and possibly with other factors. No estimate of the extent or nature of the variation can be made at this time. The influence of hereditary factors and of early environment in determining this return cannot be estimated on the basis of the scanty data available. Rich and Holmes (1928) note that more accurate returns were made by *O. tshawytscha* in the Columbia when eggs were transferred from one stream to another which was similar in nature and location to the first than when transplants were made between streams differing considerably from one another. This appears generally to be the case, as noted by Powers (1939).

RACES OF SALMON

If the salmon from two different rivers do not mix to any great extent at the time of spawning—i.e. if the majority of the fishes return for spawning to the stream in which they were hatched and reared—then we might expect that noticeable differences would come to exist between the salmon inhabiting various streams. Measurements which show this to be the case were begun on the Pacific Coast by C. H. Gilbert (1913), who applied the method of scale measurements developed in Scotland for *S. salar* to a study of the life histories of *Oncorhynchus* species. In particular the studies on *O. nerka* in the various rivers of British Columbia are of great importance (Gilbert, 1914-24; Clemens and Clemens, 1925-1937; Clemens, 1938). Certain of these measurements

have been selected out of the mass of data presented in these reports; similar results would follow from a consideration of the others.

O. nerka in British Columbia may migrate to the sea in its first year—i.e. in the summer after the eggs are hatched, or may remain for one, two, or even three years in fresh water. The adult fish may return from the sea to fresh water in the fall of its third year, or may stay in the sea in a few cases until it reaches its seventh year. The run which enters a stream will be composed of fishes belonging to several different age groups. These age groups are determined by examination of the scales, and designated by a special notation (for details, see Gilbert and Rich, 1927). The age of the fish at maturity is denoted by an Arabic numeral, while the year of its life in which it descended to the sea is indicated by a subscript to that numeral. Thus, a fish which was hatched from eggs spawned in the fall of 1930, which descended to the sea in the summer of 1931 and which returned from the sea in the fall of 1933, would belong to the 3₁ group; if on the other hand the fish, hatched from 1930 eggs, remained in fresh water until the spring of 1933, then descended to the sea, to return in 1935, it would be placed in the 5₃ group.

We will first consider the age distribution in four British Columbia river systems. The Fraser River, some 700 miles in length, is by far the largest of these; it opens into the Strait of Georgia, about 15 miles north of the southern boundary of the province. Rivers Inlet is located just north of the northern end of Vancouver Island, a little more than 250 miles north and west of the mouth of the Fraser; into it opens a small river system perhaps 50 miles in length, which includes a lake a few miles from the sea. The Skeena River, about 250 miles long,

opens into Chatham Sound, somewhat more than 200 miles north of Rivers Inlet. It is roughly paralleled over most of its course by the Nass River, which opens through Observatory Inlet into Chatham Sound a little over 50 miles to the north. In Table 3 are listed the average percentages, over a ten year period from 1926 to 1935 inclusive, of each age group in the runs of each of the four rivers. The numbers in each age-group were obtained by a study of scales from 1,000 to 2,000 individuals, taken at intervals throughout the course of the spawning run each year. It is evident that considerable differences exist. Thus, the fishes enter the southern

TABLE 3

Average percentages of age groups in runs of O. nerka to British Columbia rivers, 1926-1935 inclusive

(Calculated from data in Clemens and Clemens, 1926-37)

| AGE GROUP | FRASER RIVER | RIVERS INLET | SKEENA RIVER | NASS RIVER |
|----------------|--------------|--------------|--------------|------------|
| 4 ₁ | 78 | 62 | 52 | 20 |
| 5 ₁ | 15 | 35 | 34 | 10 |
| 5 ₂ | 3 | 2 | 10 | 65 |
| 6 ₁ | 0 | 1 | 3 | 6 |

streams at an earlier age, and leave the fresh water sooner in these rivers than in the northern ones. It is of great interest to note that the largest differences are those between the fishes of the two closest rivers—namely the Skeena, where 50 per cent of the run are 4₁ fishes, and the Nass, where only 20 per cent are to be found in this class, while the 5₂ fishes constitute 65 per cent of the total.

Measurements of the lengths of the same fishes are also available. These measurements have been analyzed by the author for the principal age groups in the runs of the Nass and Skeena Rivers for 1925, and for subsequent years as indicated in Table 4. The particular years have

been chosen on the assumption that the age at maturity is an inherited characteristic, and that therefore the progeny of the four-year-olds of 1925 will not appear until 1930. The significance of the table is not, however, dependent on this assumption. Table 5 shows the differences in length for each age group, together

stating that such a difference would have arisen due to chance variations no oftener than once in approximately 400 cases. On this basis it is evident that, with the single exception of the 5₂ males in 1925, the fishes entering the Nass River are significantly larger than those entering the Skeena.

TABLE 4

Mean lengths (inches) of O. nerka in the Nass and Skeena Rivers in certain years, calculated for the principal age groups
(From data in Clemens and Clemens)

| AGE GROUP..... | | 4 ₁ | | 5 ₁ | | 5 ₂ | |
|----------------|------|----------------|-------|----------------|-------|----------------|-------|
| Sex..... | | M | F | M | F | M | F |
| Skeena River | 1925 | 23.57 | 22.87 | 25.59 | 23.25 | — | — |
| | 1929 | 22.88 | 22.58 | — | — | — | — |
| | 1930 | — | — | 24.72 | 23.95 | 23.51 | 22.54 |
| | 1933 | 20.15 | 19.81 | — | — | — | — |
| | 1935 | — | — | 26.33 | 25.25 | 21.66 | 20.72 |
| Nass River | 1925 | 24.43 | 23.94 | 25.93 | 24.80 | 25.98 | 25.98 |
| | 1929 | 24.10 | 23.48 | — | — | — | — |
| | 1930 | — | — | 26.51 | 25.38 | 26.47 | 25.35 |
| | 1933 | 24.64 | 23.72 | — | — | — | — |
| | 1935 | — | — | 27.27 | 25.86 | 26.55 | 25.59 |

TABLE 5

Differences in mean length (inches) of O. nerka in the Nass and Skeena Rivers in certain years, with the standard errors of the differences

| AGE GROUP..... | | 4 ₁ | | 5 ₁ | | 5 ₂ | |
|----------------|--|----------------|------------|----------------|------------|----------------|------------|
| Sex..... | | M | F | M | F | M | F |
| 1925 | | 0.86 ± 0.1 | 1.07 ± 0.1 | 0.34 ± 0.2 | 1.55 ± 0.2 | — | — |
| 1929 | | 1.22 ± 0.1 | 0.90 ± 0.1 | — | — | — | — |
| 1930 | | — | — | 1.79 ± 0.1 | 1.43 ± 0.1 | 2.96 ± 0.1 | 0.81 ± 0.1 |
| 1933 | | 4.48 ± 0.1 | 3.91 ± 0.1 | — | — | — | — |
| 1935 | | — | — | 0.94 ± 0.2 | 0.61 ± 0.1 | 4.89 ± 0.1 | 4.86 ± 0.1 |

with the standard errors of these differences. The standard error is a measure of the amount of variation which might be expected in a series of samples by the operation of chance alone in the process of sampling. We will for present purposes consider a difference significant if it is as great as, or greater than, three times its standard error. This is equivalent to

Similar results were obtained in the Alaska Peninsula region by Gilbert and Rich (1926). They tagged a large number of adults of *O. nerka* near the Shumagin Islands, south of the Alaska Peninsula, and at the same time took scales from these fishes. When the fishes were subsequently recovered in Alaskan Rivers, scale studies were made to determine the ages of the

fishes. Two such series are summarized in Table 6. These data will be discussed more extensively in a later section. Data are given by MacGregor (1923) and by Snyder (1931) which permit comparison of *O. tshawytscha* in the Sacramento and Klamath Rivers, California. These data are summarized, together with the differences, in Table 7.

In addition to these actual measurements, there are many observations supported by no published data which are to be found in the literature. Thus, Royal (Pacific Fisherman, 1937) is quoted as stating that the range of weight of *O. tshawytscha* in the Skagit River, Washington, is from 28 to 34 pounds, while in the nearby Green River the range is 12 to 14 pounds. He also states that *O. kisutch* in Lake Washington is smaller than in the Skykomish River, 25 miles to the north. Alm (1934) studied the various characteristics of *S. salar* in Swedish rivers and he concludes that each of these rivers is inhabited by a population possessing distinctive and characteristic habits of growth. Calderwood (1937) mentions that *S. salar* in the River Ness, Scotland, weighs from 17 to 40 pounds, while in the River Beaulieu, opening only 7 miles farther up Moray Firth, the weight is from 8 to 10 pounds.

There is also a small amount of material indicating the existence of differences between the salmon inhabiting various tributaries of the same river system. Gilbert is said to have noted as early as 1915 the existence of two separate groups of *O. nerka* in the Nass River run. Gilbert, and later Clemens, collected data on the fishes of Meziadin Lake and of Bowser Lake, the only two known spawning grounds for *O. nerka* in the Nass watershed. For example, in Clemens and Clemens (1935), we find data which show the mean length of the Meziadin males to be

2.9 ± 0.4 inches greater than for the Bowser males, while the females of the Meziadin group are 1.2 ± 0.3 inches longer, on the average, than those of the Bowser group. Earlier data in this series make it quite probable that Gilbert's early view is correct; namely, that each of the two tributaries is used as a spawning ground by a group of fishes differing

TABLE 6

Percentage of various age groups in samples of O. nerka tagged in the Shumagin Islands and recovered in Alaskan rivers, 1923

(Gilbert and Rich, 1926)

| AGE GROUP | 4s | 5s | 5s | 6s | 6s | TOTAL NUMBER |
|---------------------|----|----|----|----|----|--------------|
| Kvichak River..... | 2 | 2 | 57 | 27 | 12 | 228 |
| Nushagak River..... | 4 | 54 | 30 | 12 | 0 | 71 |

TABLE 7

Means, differences in means, and standard errors of differences for several characters of O. tshawytscha in California rivers

(Calculated from data in MacGregor, 1923, and Snyder, 1931)

| CHARACTER MEASURED | MEAN FOR KLA-MATH | MEAN FOR SACRAMENTO | DIFFERENCE |
|--|-------------------|---------------------|----------------|
| Number of ova..... | 3754 | 7440 | 3686 ± 220 |
| Number of pyloric coeca..... | 133.8 | 176.0 | 42.2 ± 3.2 |
| Number of gill rakers on 1st branchial arch..... | 23.5 | 27.4 | 3.9 ± 0.3 |
| Length in cm..... | 80.7 | 93.3 | 12.6 ± 0.3 |

from the group found in the other. D. L. Belding (personal communication) makes the statement that the average weight of two-year maiden specimens of *S. salar* is 10.5 pounds in the main Restigouche River, New Brunswick, while in the Matapedia River, a tributary, it is 12.5 pounds, and in the Upsalquitch, another tributary, the average weight is 8 pounds.

Another characteristic which has been used to distinguish the salmon of different streams has been the time at which the mature fishes enter the river; thus, in the Columbia River, those fishes destined to travel far up the river enter early in the year, whereas those which will spawn in tributaries near the mouth enter at a later date. Rich and Holmes (1928) have shown that this time of entering fresh water is due to the influence of hereditary factors for *O. tshawytscha* in the Columbia. Fishes hatched from eggs transferred from a stream inhabited by spring run fishes to one inhabited by fall run fishes entered the Columbia in the spring, and conversely. White and Huntsman (1938), however, report an analogous experiment in which *S. salar* adopted the habits characteristic of the stream into which the eggs were introduced, instead of maintaining those of the stream in which the eggs would have been spawned.

As a result of observations such as these, the statement has been made that each stream is inhabited by a particular "race" of salmon. In view of the manifold interpretations of the term "race", it has been thought best to avoid its use. The conference on salmon problems, at Ottawa in 1938 (Huntsman *et al.*, 1939), decided that the term "local stocks" was preferable. It can, however, be said that significant differences in life history, size, or certain anatomical characteristics can be shown to exist between the fishes spawning in different streams. The question is discussed in some detail for Pacific species by Rich (1939) and generally in the discussions at Ottawa. The conclusion arrived at at this meeting may be quoted here. "The salmon of a given species may in a locality, e.g. a river, constitute a more or less distinct entity, for which the name 'stock' is to be preferred." (Huntsman, *et al.*, 1939.)

THE MOVEMENTS OF SALMON IN THE SEA

We have been concerned thus far with the return of salmon to a particular river or tributary. It has been shown that the majority of fishes marked in a given region return to that same region to spawn, and that the fishes spawning in one region differ from those spawning in another. This might conceivably come about in one of two ways. The young fishes might descend from the river into the sea and remain near the mouth of the river, ascending the same river later simply because it was the first to come to their notice. On the other hand, once in the sea, they might wander some distance away from the river in search of food and subsequently return to the same river by an active migration.

It should be worth while at this point, then, to consider the evidence which is at present available concerning each of these two hypotheses. Huntsman (1931) has described the distribution of the catch of *S. salar* in the Bay of Fundy. He notes that the fisheries depending upon the St. John River and Minas Basin salmon extend but a relatively short distance from the mouths of these rivers (Fig. 1). He states, here and later (Huntsman, 1938a), that the St. John salmon remain well within the zone in which the effects of the outflow of that river might be felt. No salmon tagged in the St. John has ever been taken in any part of the bay outside of this zone. Finally, Bay of Fundy salmon are never taken in the herring wiers at the mouth of the Bay.

However, the results summarized in Table 2 indicate that this situation is not general. Considering only the seven experiments (1, 5, 8, 9, 19, 21, and 28) in which ten or more fishes marked with a valid mark were taken in the sea, we find only two (9 and 19) in which 50 per cent or more of the recoveries were made in

the sea near the mouth of the river. When the dates on which these recoveries were made are considered, moreover, it is seen that most of the fishes taken were returning to the stream from the sea in the regular spawning run. But in view of the fact that sea recoveries depend to a great extent on the concentration of fishing activities in certain areas, confi-

return to the streams gives further support to the view that salmon go considerable distances away from their natal streams in the sea.

Huntsman (1936) has contended that those fishes which stray far from the mouth of their natal stream become lost, and either enter other streams or remain in the sea. He cites in this connection

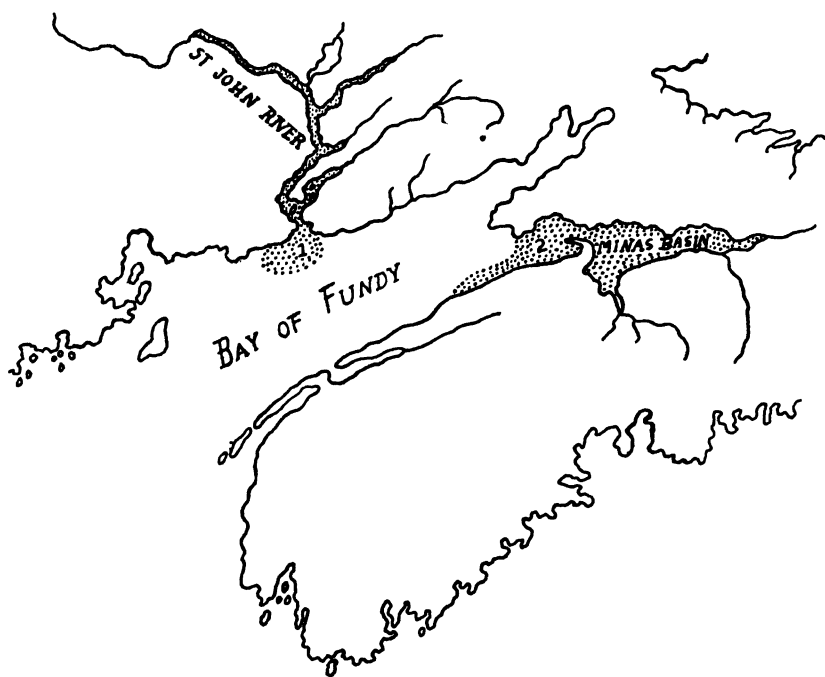


FIG. 1. DOTTED AREAS INDICATE REGIONS IN WHICH FISH (*S. salar*) FROM THE ST. JOHN RIVER (1) AND THE RIVERS OF THE MINAS BASIN (2) ARE TAKEN
(From Huntsman, 1931)

dence can be placed in these figures as indicators of the distribution of fishes in the sea only insofar as it may be supposed that, in general, fishing operations will tend to concentrate in the areas most frequented by fishes. The study of Alm (1934) indicating that all, or nearly all of the salmon (*S. salar*) from the rivers of Northern Sweden go to the southern Baltic and remain there until time to

the presence of very large salmon at the head of the Bay of Fundy, where there are no salmon streams; he presumes, without proof, that these fishes have been carried here by currents, and being lost have never sought spawning streams. More definite evidence in favor of this contention might be provided by those cases in which fishes have entered streams not those in which they were marked (Table 2, Nos. 2, 9,

11, 14, 16, 23, 28, 30). But it must be recalled that only in four of these were the streams entered situated at any great distance, and that there is some reason to suspect the validity of three of these experiments. We must say that, at present there is very little definite evidence in favor of Huntsman's view.

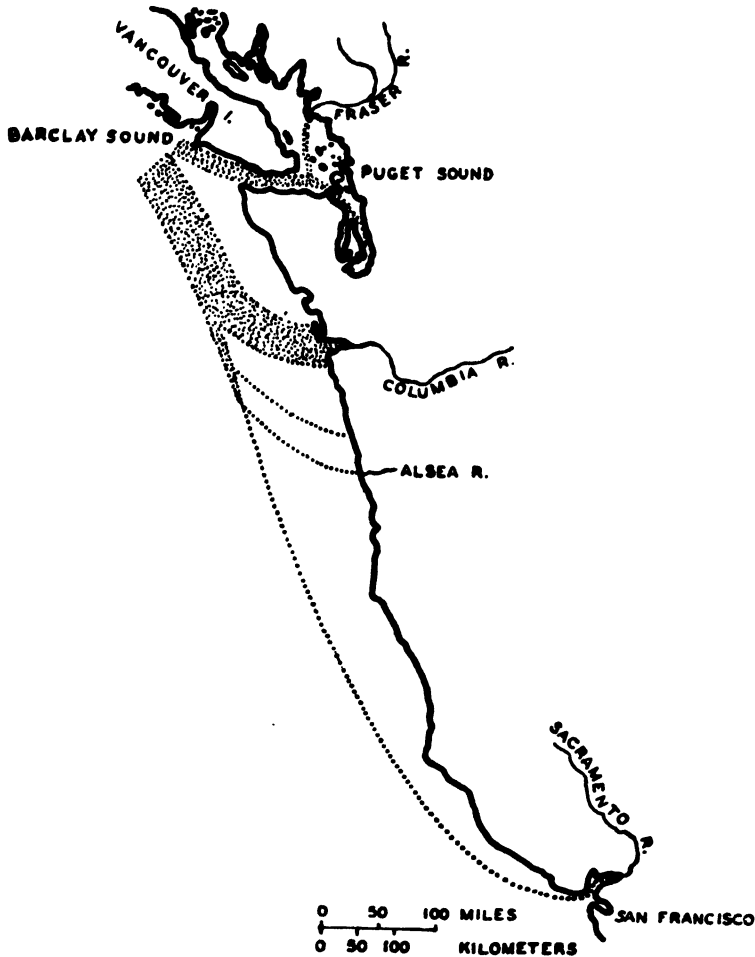
On the other hand, considering the rate of travel of which a salmon is capable and the dates and places of recovery of marked fishes, it is not improbable that, given the ability to find their way, most of the fishes recovered in distant places could have returned to their natal streams. As for the rate of travel, Gilbert and Rich (1926) report a case in which *O. nerka* traveled nearly 100 miles per day; Dahl (1938) notes, for *S. salar*, a rate of 60 miles per day for 12 days; Menzies (1937) states that a specimen of *S. salar* went 24 miles per day for 17 days, and Williamson and Clemens (1927) record, for *O. tshawytscha*, 19 miles per day for 14 days. Applying these figures to *S. salar* tagged in the Margaree River, Nova Scotia, we find in the reports of Rodd (1917-38) that the longest interval between tagging in the Margaree and recovery in Newfoundland, where most of the distant recoveries were made, was one year, eight months, and fourteen days. This fish was taken on August 1, 1932; the last day in this year on which a tagged fish was taken along the coast near the Margaree was August 20. In order to cover the distance of 400 miles in 19 days, a rate of travel of 21 miles per day would be necessary. This is entirely possible. This is the only recorded case in which such an exact comparison can be made; in the only other valid case where relatively large numbers of sea recoveries were made (Snyder, 1931) all of the fishes taken in the sea had ample time to return to the Klamath. There is one single

exception to these statements. Pritchard's (1939) experiment (Table 2, 28) has already been discussed. The 34 remote recaptures in this case were all made in the Georgia Strait region, at the time of the normal run to the Fraser River. Since six fishes were taken in the Fraser, the presumption is that all would have entered that river.

More definite information concerning the movements of salmon in the sea has been obtained by experiments in which adult fishes have been tagged in the sea. Snyder (1931) tagged 53 specimens of *O. tshawytscha* in Monterey Bay, California, and recovered fourteen of these; ten were retaken in Monterey Bay, and the others at intervals up the coast to the north, as far as 500 miles away. Much more extensive work has been carried on, largely with the same species, by the workers at the Pacific Biological Station, British Columbia. Several papers have appeared (Craigie, 1926; Clemens, 1930, 1932; Pritchard, 1930; Williamson, 1927; Williamson and Clemens, 1932). They will be summarized briefly here. Of 386 specimens of *O. tshawytscha* recovered from tagging experiments on the east coast of Vancouver Island, 252 went south to Washington, Oregon, and California, and of these, 231 entered the Columbia River (Fig. 2). Of 274 recoveries from fishes tagged on the west coast of the Queen Charlotte Islands, 20 appeared in Washington and Oregon, and of these 7 entered the Columbia River. Most of the rest of these fishes entered the rivers of the Georgia Strait-Pudget Sound region, especially the Fraser River (Fig. 3). Rich (personal communication) reports that *O. tshawytscha* has been shown to migrate from southeastern Alaska to the Columbia River. In this connection it is of the greatest interest to note that Rich and Holmes (1928) observed that a speci-

men of *O. tshawytscha* marked in the Columbia River went north as far as southeastern Alaska. We might also mention

ward entrances to the straits and channels of southeastern Alaska made extensive journeys north and south through the



**DISTRIBUTION OF
CHINOOK SALMON TAGGED IN THE SEA
BARCLAY SOUND, BRITISH COLUMBIA, 1925
(WILLIAMSON, 1927)**

FIGURE 2

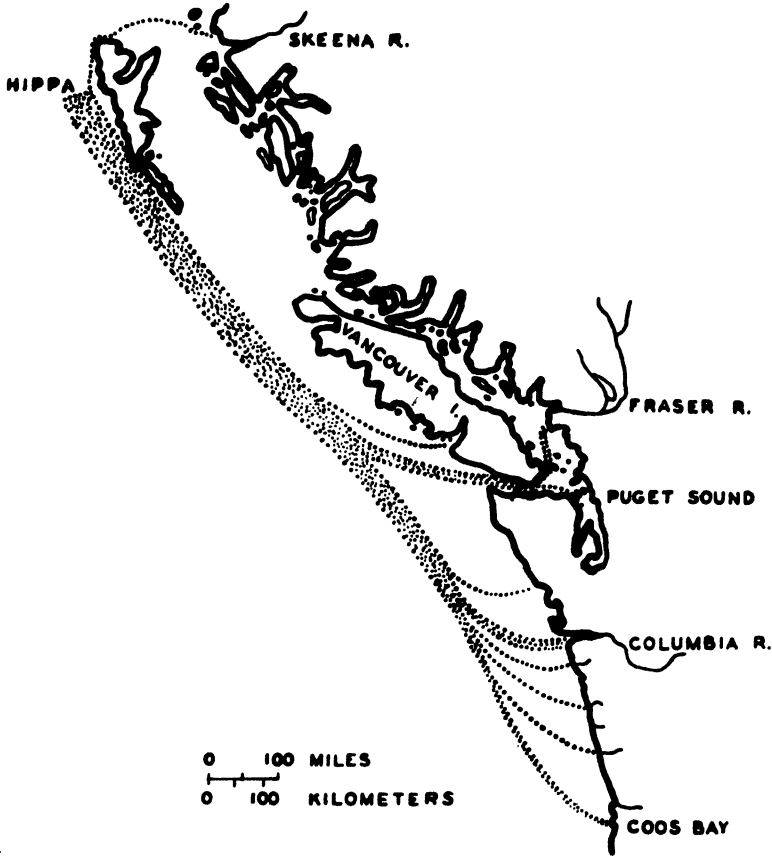
here the experiments of Rich (1926) and of Davidson and Christey (1938) which showed that salmon tagged at the sea-

complicated passages of this area. Finally, Sato (1937) has shown that *O. nerka*, *O. keta*, and *O. gorbuscha* tagged

in the sea in the Kamchatka region north of Japan disperse to many streams, some relatively remote from that region.

Only one report on the sea-tagging of

only along the coast of Newfoundland but to the Gulf of St. Lawrence shores of Canada as well. Port-aux-Basques is located at the southwestern tip of New-



**DISTRIBUTION OF
CHINOOK SALMON TAGGED IN THE SEA
HIPPA ISLAND, BRITISH COLUMBIA, 1925
(WILLIAMSON, 1927)**

FIGURE 3

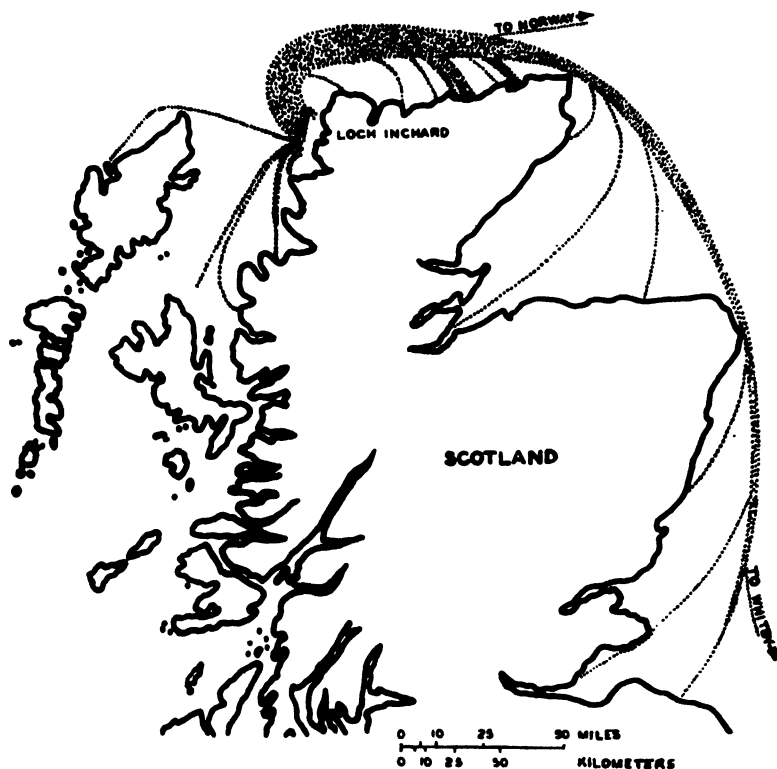
North American Atlantic salmon has appeared. Belding (1939) reports that fishes tagged in the sea off Port-aux-Basques, Newfoundland, dispersed not

foundland, on one side of Cabot Strait, one of two entrances to the Gulf of St. Lawrence from the Atlantic. This report is of interest when it is realized that many

of the fishes tagged in various Canadian streams flowing into the Gulf of St. Lawrence were later recovered in Newfoundland.

Menzies (1939) gives an excellent summary of the experiments in which Euro-

Whitby in England, while another went an equal distance across the North Sea to Sognefjord, Norway. Menzies notes that the scales of the fishes showed growth habits characteristic of the regions to which they migrated. These results,



DISTRIBUTION OF
ATLANTIC SALMON TAGGED IN THE SEA
LOCH INCHARD, SCOTLAND. 1936
(MENZIES, 1937)

FIGURE 4

pean Atlantic salmon have been tagged in the sea. Figure 4 shows the results of such an experiment (Menzies, 1937) involving the tagging of 1255 fishes at Loch Inchar, Scotland. Most of the recoveries were made along the northern Scottish coast, but one fish traveled 400 miles, to

together with those of Dahl and Somme (1935-7) have led to the belief that there is a general movement of salmon from west to east, both on the Scottish and Norwegian coasts, at the time of the spawning migration. Menzies (1939) concludes: "The whole of the experiments are not

by any means inconsistent with a feeding ground at some indeterminate distance from which an easterly migration takes the fish to the coasts after their feeding period is finished."

Finally, we will consider the experiments of Gilbert (1924) and Gilbert and Rich (1926). They tagged a large number of specimens of *O. nerka* in the Shuma-

(Fig. 5). Moreover, scales were taken from each fish at the time of tagging. Studies were subsequently made of the scales of those fishes which were recovered, and it was found that the life histories of these fishes were characteristic of the streams which they entered. Table 6 gives the results of one such series; it was known from other observations that

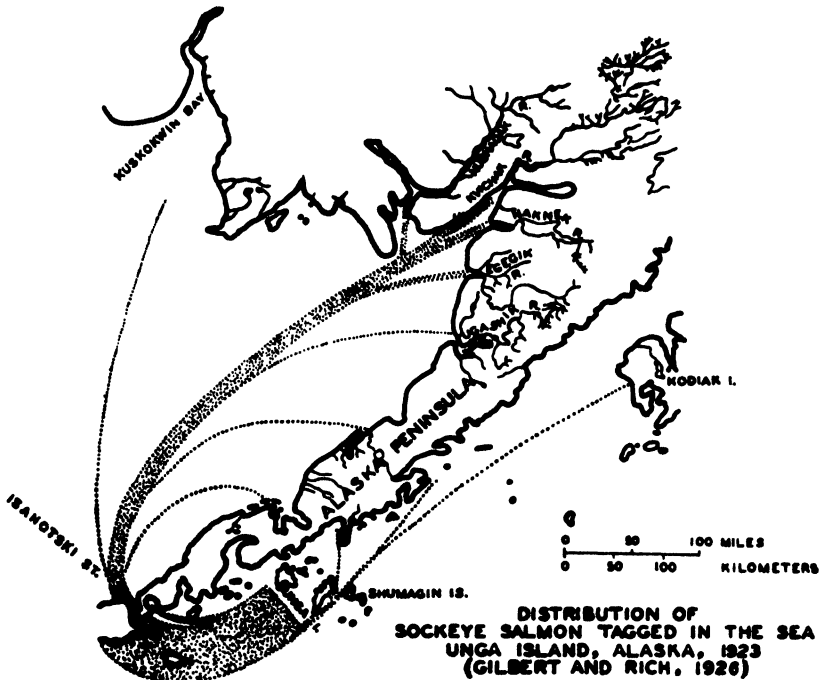


FIGURE 5

[Note: A very large number of fish are taken on the south side of Isanotski Strait, due to intensive fishing operations there. Rich (personal communication) thinks it probable that the salmon pass northward through Unimak Pass, 100 miles to the west, rather than through Isanotski Strait, as indicated here.]

gin Islands region, Alaska. Recoveries in an area where an intensive sea fishery is conducted, showed that most of the fishes taken in this region passed along the southern side of the Alaska Peninsula, around its tip to the northern side, and thence dispersed to all of the salmon streams of the Bering Sea shores of the Alaska Peninsula and of Bristol Bay

most of the Kvichak fishes normally spend two years in fresh water and go to sea in their third year; 84 per cent of the recoveries in the Kvichak showed this habit. On the other hand, most Nushagak fishes normally go to sea in their second year; 58 per cent of the recoveries showed such a record on their scales. Other differences are also evident from the table.

THE HOMING INSTINCT

It will be recalled that at the beginning of the previous section two alternative hypotheses were proposed. It was suggested that the majority of fishes from a given stream never went far from that stream in the sea, with the corollary that if they did wander off, they became lost, and were unable to return except by accident to that stream. We have seen that, while in the case of certain rivers of the Bay of Fundy, there are indications that this may be the case, there are numerous data which indicate that a certain fairly large number of fishes may leave the vicinity of the natal stream. It has been shown that these fishes would have time to return to this same stream, given the ability to find it. It has also been shown in certain cases that large-scale movements of fishes over distances of several hundred miles take place; in a few instances, different fishes have been shown to cover the same lengthy migratory courses in opposite directions, as, for example, the movements of *O. tshawytscha* from the Columbia River to southeastern Alaska, and from Alaska to the Columbia River. Finally, in two cases, numbers of sea-tagged fishes have traversed considerable distances and later entered streams normally inhabited by fishes having life histories similar to those shown by the scales of the tagged fishes.

All of these facts are much more easily explained by the second hypothesis, namely, that fishes may leave the general vicinity of their natal streams and travel considerable distances in the sea, but that the majority of such fishes subsequently return to the same stream. In addition, certain results cited in earlier sections are in accord with this hypothesis. That the salmon possesses some ability to follow a definite migratory course is shown by the fact that a certain

degree of return to individual tributaries has been demonstrated in certain large river systems. If we assume that any or all of the anatomical and other distinctions demonstrated to exist between the populations of different streams are hereditary or are determined by the fresh-water environment, then it necessarily follows that no great admixture of populations between the two streams at spawning time can take place. In certain geographical situations it is absolutely essential that the majority of the fishes definitely choose the stream from which they originally entered the sea, if this admixture is to be prevented. This is true for *O. nerka* in the Nass and Skeena Rivers, for example, where the Nass fishes must pass near the mouth of the Skeena on their riverward migration; nevertheless constant differences in life history between the stocks of the two streams have been observed over a period of 25 years at least. Other examples are numerous.

It is of course true, as Huntsman (1937) has pointed out, that the most convincing proof of this second hypothesis which could be provided would consist of an experiment in which fishes indisputably originating in a certain stream were tagged in the sea and subsequently recovered in that same stream. It is to be hoped that this experiment will at some time be performed, although the technical difficulties are very great. It is also true that most of the experiments described in this paper were not designed for the express purpose of determining the sea range of salmon which subsequently return to their natal streams. In consequence, we cannot regard this particular question as entirely settled. Furthermore, there are undoubtedly differences between the individual species treated here which will appear on further study. It is, however, the opinion of the author that the weight

of the evidence at present available is distinctly in favor of the parent stream theory, which we may state thus: Anadromous salmon or trout hatched and reared in a particular region will, upon returning to fresh water, return in the great majority of cases to that same region, even from considerable distances. It is to be hoped that this will be more extensively tested in the future. It is also especially to be desired that attempts will be made to define more closely the nature and size of the region to which a given group of fishes will return, and to study the variations with species and locality. The inadequacies in our knowledge of these and other matters were pointed out by the participants in the Ottawa symposium (Huntsman *et al.*, 1939).

THE NATURE OF THE HOMING INSTINCT

The existence of a certain ability to follow a definite migratory course leads naturally to the question, what sense or senses are involved? Very few attempts appear to have been made to answer this question. Ward (1921a, b, 1939a, b) studied *O. nerka* in the Copper River, Alaska, and concluded that when presented with a choice between two tributaries, the salmon invariably chooses the one with the cooler water. He has also applied this to *O. nerka* in the Skagit River, Washington. Powers (1939) has attributed the direction taken by *O. nerka* to (a) gradients of salinity in the sea, and (b) gradients of carbon dioxide tension in the sea and in the rivers. Although the suggestions made by these writers are of some value in indicating possibilities, neither has taken into consideration the fact that a run of fishes, whether in the sea or in a river, may divide, some passing into one river or tributary while others continue in their previous course. Neither author is willing to agree with the parent

stream theory as stated above. Craigie (1926) sectioned the olfactory nerves of specimens of *O. nerka* captured in the Georgia Strait region; his results were inconclusive. We must then say that at present we know little or nothing about any mechanism which might enable the salmon to find his way to a particular stream or tributary. Indeed, we may say, as Sumner (1939) has, that it is difficult to see how any known sense or combination of senses would be adequate, in view of the fact that variations in a certain property of a given stream might be greater from year to year than would be the differences between that stream and a nearby one. Studies directed at this feature of the "homing" question should prove of the greatest interest.

SUMMARY

1. Specimens of *S. salar*, *S. gairdnerii*, *O. nerka*, *O. tshawytscha*, *O. gorbuscha*, and *O. kisutch* reared, marked, and liberated in a particular river have been shown to return, in the great majority of cases, to that same river.

2. There are very few cases in which it has been shown convincingly that individuals of any of these species have entered streams 100 or more miles from the one in which they were reared.

3. There is some evidence that fishes reared in small rivers will stray in small numbers to similar streams not more than 50 miles away.

4. When eggs spawned in a particular tributary are hatched and the young fishes reared in that same tributary, most of the adult fishes will return to the tributary (*O. nerka*, Fraser River; *O. tshawytscha*, Columbia River).

5. Demonstrable differences in life history, in certain anatomical features, or in both exist between salmon of the same species breeding in adjacent rivers (*O.*

nerka, *O. tshawytscha*, *O. kisutch*, Pacific coast of North America; *S. salar*, Scotland, Sweden).

6. Similar differences exist between the salmon inhabiting different tributaries of the same large river system (*S. salar*, New Brunswick; *O. nerka*, British Columbia; *O. tshawytscha*, Columbia River).

7. Except for those cases in which the principal fishery depends upon the riverward migration of fishes, and centers around the mouth of the river, the majority of recoveries of marked fishes at sea have been at considerable distances from the river in which they were marked (*S. salar*, Sweden, Scotland, Canada; *O. tshawytscha*, California).

8. Practically all of the fishes recovered in the sea at considerable distances from their natal streams could have returned to them in time to enter with the normal run, granted the ability to find the stream.

9. Fishes tagged in the sea in certain areas will subsequently disperse to a variety of streams, some at considerable distances (*O. nerka*, *O. keta*, *O. gorbuscha*, Japan; *O. nerka*, Alaska; *O. tshawytscha*, British Columbia, California; *S. salar*, Newfoundland, Scotland, and Norway).

10. Young specimens of *O. tshawytscha* marked in the Columbia River may go north as far as southeastern Alaska; adults tagged in southeastern Alaska or farther south may go to the Columbia River.

11. Specimens of *S. salar* tagged in the sea off Scotland and of *O. nerka* tagged in Alaska have later appeared in streams remote from the region of tagging; scales from these fishes gave evidence of life histories otherwise known to be characteristic of the streams they later entered.

12. The hypothesis most compatible with these facts is the following: Anadromous salmon and trout hatched and reared in a particular region will, when seeking fresh water to spawn, seek out and return in the great majority of cases to the same region, even from considerable distances.

13. No mechanism is known by means of which fishes could so return.

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EFFECTS OF FEEDING THYROID SUBSTANCE (*Concluded*)

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THE EFFECTS OF THYROID ON TISSUES IN GENERAL

ATTEMPTS have been made to show the universal action of thyroid on protoplasm by treating isolated vertebrate, invertebrate, and plant tissues with extracts of the vertebrate gland. Thus Carrel (1913) found that connective tissue (periosteum) grew faster *in vitro* under the influence of thyroid than without thyroid. Ebeling (1924) found that thyroid epithelium in pure culture secreted substances which, like extracts of the thyroid gland, accelerated cell division of fibroblasts *in vitro*. Sato (1930) demonstrated that synthetic thyroxin in 1:100,000 dilution accelerated the growth of cultivated heart tissue and fibroblasts of the chick embryo, as well as cultivated lung tissue of the rabbit embryo. In 1:500,000 dilution, synthetic thyroxin also stimulated growth of cultivated chicken myxosarcoma *in vitro*.

Hopping (1931) found that the blood from an alligator injected with thyroxin (Squibbs) 3 days previously to the test showed an increase in metabolism of from 150 to 190 percent above the control (normal alligator's) blood. Davis, Da Costa and Hastings (1934), studying the tissue metabolism of excised frog heart, found that after treatment for 24 hours with a concentration of 1 mgm. per 100 cc. of thyroxin, the mean oxygen con-

sumption had increased 55 percent, while the control had decreased 17 percent. Markowitz and Yater (1932) made a study of the action of thyroxin on cultures of pulsating fragments of heart muscle removed from two-day-old chick embryos. The thyroxin (1:500,000 dilution) increased the frequency of pulsations and contractions of the isolated tissues from 100 per minute to 226 per minute, after 24 hours of treatment. Gerard and McIntyre (1932) fed young dogs with 0.6 gm. of desiccated thyroid per kilo per day for a period of 3 to 6 weeks. At the end of the feeding period, it was found that isolated liver, heart, and vagus nerve tissues had an average increase of 25 percent in oxygen consumption, as compared with the oxygen consumption of identical tissues from normal dogs.

The experiments of Hicks (1932) showed that the oxygen consumption of finely minced rat muscle tissue at 37°C. was increased by 20 per cent when the animal received hypodermic injections of 0.7 mg. thyroxin weekly for 6 weeks prior to the isolation of tissue. Dye (1933) studied the effects of thyroxin on tissue respiration, and found that when pups approximately 3 months old were fed large doses of thyroxin (168 mgm. each in 35 days), their isolated muscle tissues showed an increase in oxygen consumption of 50 percent as compared with oxygen consumption of similar tissues from normal

dogs. McEachern (1935) reported some experimental work on the metabolism (as measured by Warburg's method) of diaphragm muscle, and of hepatic and renal tissues of the white rat following subcutaneous administration of thyroxin.

small (up to 28 percent) and variable increase in the respiration of hepatic and renal tissues. The respiration of muscle tissues underwent no significant change. Induction of hyperthyroidism by multiple injections of the above-mentioned

TABLE 1

Comparison of total metabolism of normal and hyperthyroid animals to QO_2 and QN_2/G of their isolated tissues

Determination of tissue metabolism based on 1-hour period. (From McEachern, D., 1935. Bull. Johns Hopkins Hospital, Vol. 56, pp. 145-179.)

| DATE | THYROXINE | | | ANIMAL | | | KIDNEY | | | LIVER | | | DIAPHRAGM | | |
|---------------------|-------------------------|-----------------|----------------|--|-----------------|--------------------|-----------------|--------------------|--------------------|-----------------|--------------------|--------------------|-----------------|--------------------|--------------------|
| | Milligrams per kilogram | Number of doses | Number of days | B.M.R. cm ³ per gram per hour | | | QO ₂ | Per cent increase† | QN ₂ /G | QO ₂ | Per cent increase† | QN ₂ /G | QO ₂ | Per cent increase† | QN ₂ /G |
| | | | | Normal | After thyroxine | Per cent increase† | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| <i>Normal</i> | | | | | | | | | | | | | | | |
| 1933 | | | | | | | | | | | | | | | |
| 1/20 | | | | 1.28 | | | 29.10 | | | 10.63 | | | 4.69 | | |
| 1/26 | | | | 1.11 | | | 24.62 | | 4.72 | 8.54 | | 1.16 | 4.42 | | 4.36 |
| 2/15 | | | | 1.31 | | | 21.40 | | 3.41 | 9.87 | | 2.32 | | | 4.21 |
| 3/13 | | | | 1.13 | | | 21.00 | | 2.68 | 7.26 | | 1.04 | 6.13 | | 4.18 |
| 3/8 | | | | 1.02 | | | 27.10 | | 2.82 | 7.70 | | 1.16 | 5.37 | | 5.43 |
| 2/22 | | | | 1.26 | | | 20.92 | | 1.35 | 10.53 | | | 5.59 | | 4.42 |
| Mean..... | | | | 1.18 | | | 24.02 | | 2.99 | 9.09 | | 1.42 | 5.24 | | 4.52 |
| <i>Hyperthyroid</i> | | | | | | | | | | | | | | | |
| 3/23 | 1.0* | 6 | 6 | 1.17 | 1.84 | 57.2 | 44.90 | 84.0 | 3.92 | 13.80 | 58.6 | 1.63 | 7.13 | 40.3 | — |
| 2/3 | 10.0 | 3 | 7 | 1.16 | 1.93 | 66.4 | 40.50 | 67.0 | 7.48 | 15.60 | 79.0 | 1.80 | 6.23 | 22.6 | 4.12 |
| 1/20 | 10.0 | 3 | 4 | 0.97 | 1.98 | 104.0 | 36.00 | 47.6 | — | 15.55 | 79.0 | — | 6.12 | 20.4 | — |
| 3/7 | 2.5 | 12 | 14 | 1.14 | 2.09 | 83.5 | 37.24 | 53.6 | 4.92 | 12.78 | 47.0 | — | 8.50 | 67.3 | 3.55 |
| 1/25 | 20.0 | 4 | 8 | 1.18 | 2.26 | 91.6 | 34.50 | 42.2 | 7.35 | 11.56 | 33.0 | 4.72 | 8.55 | 68.0 | 3.38 |
| 3/6 | 2.5 | 11 | 12 | 1.08 | 2.30 | 113.0 | 35.50 | 45.6 | 4.66 | 10.90 | 25.3 | 1.25 | 10.33 | 103.5 | 4.10 |
| 2/9 | 0.66* | 9 | 9 | 1.23 | 2.57 | 109.0 | 42.90 | 75.8 | 5.17 | 12.70 | 46.0 | 1.26 | 9.24 | 82.0 | 5.63 |
| Mean..... | | | | 1.13 | 2.14 | 89.3 | 37.77 | 57.2 | 5.70 | 13.18 | 45.0 | 2.13 | 8.01 | 52.7 | 4.16 |

* Grams B.D.H. thyroideum siccum by mouth per day.

† Increase above average of normal series.

Control experiments were made in each case with tissues from normal animals. At varying time intervals (22 hours to 8 days) following the administration of a single dose of 10.0 mgm. thyroxin per kilogram of body weight, there was a

dosage, brought about large and constant increases in tissue respiration. In 12 experiments, the mean increase was 46 percent for kidney, 73 per cent for liver and 75 percent for muscle. A summary of McEachern's work is shown in Table 1.

Work on thyroid treating of invertebrate tissues has yielded a variety of noteworthy results. The respiration of fresh, dried, and powdered tissues of various invertebrates with and without addition of thyroid extract, was measured by the Barcroft-Warburg technique by Ashbel (1935). It was found that in the case of eggs of *Bombyx mori* during aestivation and incubation, thyroid extract caused an increase of oxygen consumption up to 23 percent. On hibernating eggs of the same form the effect of thyroid extract was even more marked, the oxygen consumption being increased up to 3700 percent. With whole and various portions of the silk glands of *Bombyx mori*, oxygen consumption was increased up to 15 percent. An increase up to 300 percent in oxygen consumption was noted with thyroid treating of unfertilized eggs and with ovaries of the echinoderm, *Spheroecinus granularis*. With fertilized eggs in all stages of development in the crustaceans *Carcinus moenas*, *Eupagurus prideauxii*, *Portunus corrugatus*, and *Portunus holstatus*, an increase up to 300 percent was noted in oxygen consumption. With the fertilized eggs of the mollusk, *Aplepia limacina*, an increase up to 200 percent was noted. With the ovary of the tunicate, *Ciona intestinalis*, an increase of oxygen consumption up to 360 percent was noted. In every case the action of the thyroid extract was identical on the uninjured and freshly macerated tissues. The action of the thyroid extract was even more marked on suspensions of tissues which had been dried and powdered. Increases in oxygen consumption of dried tissues were noted as follows: up to 5,000 percent with powdered eggs of *Bombyx mori*; 3,000 percent with powdered silk glands of *Bombyx mori*; 9,300 percent with powdered ovary of *Echinoderma*; 4,000 percent with powdered eggs of crustaceans;

2,700 percent with powdered eggs of mollusks; and 30,000 percent with powdered ovary of tunicates. In the case of suspensions of powdered tissues which had been standing for months (eggs and silk glands of *Bombyx mori*) and showed almost zero oxygen consumption, the addition of thyroid extract caused an almost immediate restoration of oxygen consumption. All the experiments were made with the thyroid extract "Elyteran" (Bayer). Synthetic thyroxin appeared to have no effect on the oxygen consumption of these invertebrate tissues.

Studies on thyroid treating of plant tissues have effectively contributed to our knowledge of the effects of the hormone on protoplasm in general. Imshenetskii (1932) studied the effect of thyroid extract (thyroidin) on *Saccharomycodes ludwigii*, *Mucor guilliermondii*, *M. racemosus*, *M. ramonnanus*, *Rhizopus nigricans*, *Bacillus megatherium* and *B. mycoides* by adding dilute solutions (0.02 percent to 3.0 percent) of the extract to the food medium. It was found that spore formation in yeasts and molds was stimulated, and their rate of reproduction was increased. The effect on spore formation in bacteria was slighter, and no effect on the rate of reproduction was noted. A 0.5 percent concentration was found to be optimal, and the greatest stimulation occurred during the first 48 hours of treatment. Thyroxin in concentrations of 1:9,000, 1:6,000 and 1:3,000 had no effect on spore formation or reproduction of any of the above-mentioned forms. Buddington (1919) in his experiments with bulbs of *Allium* grown in Pfeffer's solution discovered that the growth of the root tips was retarded in proportion to the amount of thyroid material used. He noted further that the early leaves were not affected by the presence of thyroxin, and that general growth was not affected

by iodine compounds. Rebello (1924), studying the effect of thyroid on hyacinth bulbs, found an acceleration in growth when he used a powdered extract of the gland. Fresh thyroid seemed to have no effect on the growth of the bulbs. Buddington (1925) found that the root tips of *Narcissus* bulbs growing in Pfeffer's solution, to which had been added thyroid gland substance, showed a growth markedly abbreviated as compared with the controls. With the shorter length was associated differentiation of special root tissues nearer and nearer the root tip, and in all cases much nearer than in the controls. It was concluded that thyroid substances cause precocious differentiation in both plant and animal tissues. This was held to suggest that animal and plant protoplasts are near enough alike physiologically to respond similarly to the same endocrine substance. Hence, it is concluded that thyroid substances are influential in essentially the same manner on all protoplasm.

The work of Davis (1934) confirmed the findings of Buddington. Experiments were made in which *Allium* and *Narcissus* bulbs and *Vicia faba* plants were treated with injections of thyroid material, and seedlings of *Pisum sativum* were grown in solutions containing thyroxin. The time of flowering of *Allium* and *Narcissus* was hastened in the thyroid treated plants. *Allium* plants showed an average acceleration of 16 percent in time of flowering, and in height and number of flower stalks. Acceleration in the flowering time of *Narcissus* occurred also, but was not as marked as in *Allium*. In general, the green vegetative parts of the treated plants were depressed in growth, although they sometimes showed an early temporary acceleration. *Vicia faba* showed a depression in growth in 75 percent of the observations, and *Pisum* was depressed in 88 percent of the cases.

The above observations on the effect of thyroid on protoplasm in general point to several fundamental conclusions. First, the metabolic processes of vertebrate, invertebrate, and plant tissues are accelerated by the addition of thyroid substance to the culture medium, or by thyroxin injections prior to isolation of the tissues. Secondly, the accelerated metabolic processes of isolated tissues result in reactions similar to those in the living vertebrate organism. The acceleration in metabolism of isolated animal tissues due to thyroid treatment may result in either increased oxygen consumption or accelerated cell division or both. In the case of accelerated cell division, the dosage or concentration of thyroid is undoubtedly of a nature conducive to a predominance of anabolic over katabolic metabolism. In cases where cell division is retarded, there is still an increase in oxygen consumption, resulting from a predominance of katabolism. As was observed in the thyroid treatment of vertebrate organisms, the dosage is the factor which determines the predominant phase of metabolism in the isolated tissue.

The above facts point to no other logical conclusion than that thyroid extract or the isolated hormone, thyroxin, in association with isolated vertebrate, invertebrate, or plant tissues, cause an acceleration in one or the other, or both (anabolic and katabolic) processes of metabolism. In this respect the above-mentioned tissues may be considered as near enough alike physiologically to respond to the same endocrine substances. Hence, thyroid undoubtedly exerts its metabolic regulator activity on all protoplasm irrespective of the organism into which it is built.

THYROID FEEDING OF INVERTEBRATES

Other investigations which have added to our knowledge of the effects of thyroid substance on protoplasm in general have

been the studies on thyroid feeding of invertebrates. Up to the present time, no one to our knowledge has demonstrated the presence of an active thyroid gland in any invertebrate organism. A study of the effects of thyroid feeding on invertebrates is of prime importance then in determining whether or not organisms that do not naturally possess any thyroid structure will respond to the action of thyroid secretion. A knowledge of these effects should lead to some conclusion as to whether or not the thyroid is effective in the same physiological manner on organisms throughout the animal kingdom. The work concerning the thyroid feeding of invertebrates has been centered largely around the protozoa and insects.

The effect of thyroid feeding on protozoa was first studied by Nowikoff (1908), who observed that *Paramecia* fed with an extract of the vertebrate gland seemed to divide more rapidly than those kept in ordinary hay infusions. Nowikoff used Merck's Glandula thyroidea dissolved in distilled water, shaken and filtered several times through paper and finally diluted to a one or two percent solution. A number of *Paramecia* (1 to 3) were placed in a few drops of this extract on a slide; other individuals for controls were placed in a similar quantity of hay infusion medium. The cultures were kept in a moist chamber and observed daily. The observations indicated a larger number of individuals in the thyroid medium than in the hay infusion. Shumway (1914) criticized Nowikoff's method of experimentation, saying that the earlier worker had not made corrections for the toxic effects resulting from excretory products when a group of individuals is kept in the same medium for a number of days. Another source of error in Nowikoff's work was found in the fact that he made no attempt to secure closely related *Paramecia* for the experiment, the necessity for which is shown by the great

variability in reaction and viability possessed by different races and individuals of this form. The experiments of Shumway (1914) were based on a pedigreed line of *Paramecium aurelia* during the life history of 420 generations. The medium in which the control line was kept was prepared by boiling one gram of hay in 100 cc. of tap water for 10 minutes, filtering and allowing it to stand for 24 hours, when it was mixed with an equal quantity of tap water. The experimental lines were treated with the regular control medium to which was added small quantities of thyroid or thymus material. No attempt was made to render the extracts absolutely bacteria-free. The individuals treated with thyroid were as a rule more active, and slightly smaller than the control individuals, and their protoplasm was more transparent. The thymus treated individuals, on the other hand, were more sluggish, larger, and darker than the controls. The conclusion was drawn that the lighter color and smaller size of the thyroid individuals were effects due to accelerated processes of metabolism (faster digestion, excretion, etc.), whereas the appearance of the thymus fed was due to the presence of undigested food granules. The experiments showed that thyroid extract greatly increased the rate of division of *Paramecium*, except at the time when the line was nearing the close of its cycle. This effect was not permanent, but disappeared when the thyroid feeding was stopped. Similar treatment with thymus extract gave no accelerating effect in the rate of division. The conclusion was drawn that thyroid directly affects the metabolic activities of the cell, hence leading to a faster rate of division. A very thorough study made later by the same worker (1917) substantiated his earlier work. It was shown that thyroid substance fed to *Paramecium aurelia* or *P. caudatum*, either as an emulsion of raw thy-

roid or as a suspension of the commercial powder, produced a constant and significant increase of 65 percent in the rate of division as compared with that characteristic of individuals grown in an ordinary hay infusion medium. It was noted further that the thyroid was the only one of the organs of internal secretion that produced this effect on *Paramecium*, and that boiling the extract had no effect on its potency. As in the earlier work, it was found that *Paramecia*, after prolonged thyroid feeding, revert to the normal rate of division when returned to the control diet.

TABLE 2

Division rate of Paramecium

Race A. Summary of experiments. Average division rate per day. (From Shumway, 1917. Jour. Exper. Zool., Vol. 22, pp. 529-563).

| EXPERIMENT | CONTROL | THYROID | DAYS |
|-------------|---------|---------|------|
| I | 1.40 | 2.80 | 35 |
| II | 1.65 | 3.10 | 15 |
| III | 2.65 | 3.20 | 5 |
| IV | 1.90 | 3.20 | 10 |
| V | 0.70 | 3.70 | 5 |
| VI | 2.00 | 2.55 | 10 |
| VII | 2.40 | 3.20 | 15 |
| VIII | 1.50 | 2.65 | 5 |
| IX | 0.70 | 0.85 | 20 |
| Average.... | 1.60 | 2.65 | 120 |

Iodothyrim and iodine failed to produce the thyroid effect. Shumway's data are summarized in Table 2.

Buddington and Harvey (1915) determined the effects of the thyroid from a variety of vertebrates on the division rates of ciliate protozoa. Perfectly fresh glands were taken from the fresh water sucker (*Catostomus teres*), the frog (*Rana pipiens*), the turtle (*Cistudo carolina*), the chick (*Gallus domesticans*), and the cat, (*Felis domestica*), dried, powdered, and kept in closed containers until used. The forms used for experimentation were *Stylonicchia*

and *Paramecium*. Every one of the gland substances used produced an acceleration in cell division of the ciliates. The effect was small for the fish thyroid and progressively larger in ascending the phylogenetic scale to the cat, so that the average effect was something of the order of a 300 percent increase in rate of division. This led the writers to the conclusion that the physiological qualities of the thyroid glands of the phylogenetically "higher" and "lower" vertebrates are constant and similar in all. The findings reported in the above three mentioned papers have generally been cited as a corroboration of the view that the active principle of the thyroid directly accelerates metabolism.

In complete contradiction to the above conclusions are the findings of a group of later workers. Riddle and Torrey (1923), studying the effect of thyroxin on *Paramecium* reported a slight decrease in cell division and a large increase in excretory activity in the organisms living in a culture medium to which the crystalline hormone had been added. On the basis of 18 experiments, where observations were made for periods ranging from 7 to 71 days, the mean decrease in cell division in the thyroxin cultures was 4.54 percent. These authors emphasized the contrast between their observations and those of Shumway (where a large increase in cell division of *Paramecia* followed thyroid feeding) and suggested that factors in the thyroid other than thyroxin may have been responsible for Shumway's results. The acceleration in excretory processes in *Paramecia* was indicated by an increase in the number of accessory canals, and by a great decrease in the number of excretory crystals in the endoplasm. These investigators concluded that thyroxin promotes katabolism rather than anabolism, hence the slower division, and faster excretion of *Paramecia* when treated with the hormone. This

conclusion was also reached by Woodruff and Swingle (1923) who investigated the influence of thyroid products on protozoa by a series of experiments on a pedigreed race of *Paramecium*. The results showed in a clear cut manner that neither thyroxin (Squibb's) nor commercial desiccated thyroid, or fresh desiccated thyroid of the turtle produced any significant acceleration in the rate of division in *Paramecium*. These workers expressed the opinion that results to the contrary, published by previous investigators were attributable to variations in the bacterial food supply which the different media afforded the *Paramecia*. Accordingly they believed all the studies showing that thyroid products accelerate cell anabolism and consequent division to be erroneous. Torrey (1923) repeated the experiments on thyroxin treatment of *Paramecium* mentioned above (Riddle and Torrey, 1923), and found the division rate of thyroxin lines to be only about one-third the rate exhibited by control lines. In this investigation, the experimental animals were raised in a medium containing 0.0001 percent thyroxin in N/5000 NaOH; the controls in the same medium less thyroxin. Later (1924) Torrey confirmed his earlier work on the effect of thyroxin on *Paramecium*, showing that the hormone depressed cell division independently of the food supply and hydrogen ion concentration of the medium. The conclusion was reached that the depressant action of thyroxin increased directly with the concentration but with decreasing increments.

Cori (1923) studied the effects of both thyroid and thyroxin on the division rate of *Paramecia* and reached some fundamental conclusions. Ordinary hay infusion was the medium used for the controls, while filtered thyroid solution in concentrations of 1:100, 1:200 and 1:300, and thyroxin solutions of 1:100,000 were

added to the medium of the experimental animals. It was found that a faintly alkaline thyroid extract of 1:200 strongly accelerated the rate of cell division in *Paramecium putrinum*. An equivalent concentration of thyroxin (1:100,000) in hay infusion only slightly accelerated the rate of cell division. His data are summarized in the following tabulation:

Number of divisions in 24 hours averaged from 5 sister cultures in 5 days

| | | | | | |
|-----------------------|------|------|------|------|------|
| For control | 4.53 | 4.87 | 3.53 | 5.00 | 5.04 |
| For thyroxin | | | | | |
| 1:100,000 | 4.72 | 5.00 | — | 4.95 | 5.22 |
| For thyroid 1:100 — — | — | — | 3.91 | 5.40 | 5.70 |

The average ratio was control: thyroxin: thyroid = 100:102:112.

The suggestion was made that thyroid extract must contain some active principle other than thyroxin, which accelerates the division rate of *Paramecia*. If this were true some of the contradictions among earlier investigators would become reconciled.

The work of Cori was substantiated by the experiments of Torrey, Riddle, and Brodie (1925). These investigators found that thyroxin in concentrations ranging from 1:10,000 to 1:1,000,000, affected *Paramecia* the same as total thyroid in accelerating certain processes of metabolism, especially those concerned with excretion. However, thyroxin had an effect exactly opposed to that of thyroid on the rate of cell multiplication. Whereas the thyroid accelerated cell division, thyroxin depressed the division rate of *Paramecium* in a degree directly proportional to its concentration. The conclusion was reached that the decrease in rate of cell division in *Paramecium* was due to the action of thyroxin on the organisms themselves, and not to changes in food supply.

The observations of Torrey (1928) on thyroxin treatment of the fertilized egg of

several invertebrates are entirely in accord with those of Cori and others on thyroxin treatment of *Paramecium* mentioned above. Eggs from the sea-urchin, *Echinometra lucunter*, and the ascidian *Phallusia nigra* were fertilized and kept in sea water containing thyroxin in concentrations varying from 1:50,000 to 1:1,600,000. The heavier concentrations completely inhibited the cleavage of the majority of eggs of *Echinometra*, and hastened their disintegration. In the lighter concentrations a similar effect was observed, though decreasing as the concentration decreased. With *Phallusia*, the results were somewhat similar to those obtained for *Echinometra*. In the heavier concentrations, cleavage began later and involved fewer eggs, gastrulation occurred later, and the larvae 5.5 hours after fertilization were inferior both in number and in development as compared with controls. In the lighter concentrations, the effect was less drastic, though even in the dilution of 1:1,000,000 there was a general retardation of about 10 percent in development. In the light of studies on the effect of thyroxin on division rate of Protozoa the above results obtained by Torrey do not present any great difficulty. In the Protozoa, it was noted that whereas thyroid extract accelerated total metabolism (anabolism and katabolism) the isolated hormone, thyroxin, accelerated only the katabolic processes. An accelerated rate of katabolism was in all probability responsible for the retarded division rate of Torrey's invertebrate eggs treated with thyroxin. It is of interest here to note the similarity in reaction of a phylogenetically 'low' organism (Protozoa) and the immature stages of phylogenetically 'higher' organisms (*Echinometra* and *Phallusia*). On the basis of the recapitulation theory, the sea-urchin and the ascidian at some early age pass through a stage in development

which is physiologically if not anatomically similar to the Protozoa. The similarity in reaction of the 2-to-8 cell stages of *Echinometra* and *Phallusia* to that of *Paramecium*, insofar as thyroxin is concerned, would seem to bear out this point beautifully. Butler (1928) confirmed Torrey's conclusions in a report on the effect of various concentrations of thyroxin on the cleavage rate of *Arbacia* eggs. Thyroxin in sea water in a concentration of 1:50,000 retarded the first cleavage of the eggs of *Arbacia punctulata* by about 5 minutes. This retardation persisted through all the later cleavage stages. A concentration of 1:100,000 produced a retardation in cleavage, though to a lesser degree than the first dosage. In a concentration of 1:25,000 retardation in the rate of division was about twice that produced by the 1:50,000 solution.

Susaceta (1930) also confirmed the work of Torrey, and further substantiated the observations on the differential effects of thyroid and thyroxin on lower invertebrate organisms. In this study, the cleavage stages of the Pholadid mollusk *Barnea caudida* were subjected to several concentrations of synthetic thyroxin and thyroid extract. Thyroxin, in all concentrations showed a retarding influence on the rate of development of this form. Up to concentrations of 5 cc. per liter, the thyroid produced a slight acceleration; above that dosage there was a variable retardation. The 2-and-4-cell stages were especially susceptible in all cases. The retarding effect of thyroxin in this case may well have been explained in terms of accelerated katabolism, while the thyroid effect was undoubtedly due to an acceleration of total metabolism.

From the above investigations it is evident that thyroid extract and the isolated hormone, thyroxin, affect the metabolic processes in the single cell of *Paramecium*,

and in the early cleavage stages of other invertebrates. Thyroid apparently accelerates both anabolism and katabolism, resulting in an increased rate of cell division and excretion. Thyroxin, on the other hand, seems to affect only the katabolic processes in the cell, hence the accelerated rate of excretion and the slightly depressed rate of cell division.

The effect of thyroid feeding on insects has been studied by several workers. Kunkel (1918) found that feeding the larvae of *Lucilia caesar*, *L. sericata* and *Calliphora erythrocephala* exclusively upon mammalian thyroid tended to retard slightly the growth of the larvae, and consequently to reduce the size of the resulting pupae, as compared with the muscle- or thymus-fed controls. His studies showed also that thyroid tended to hasten the onset of pupation (shorten the larval period) and shorten the period of pupation. This worker noted that the hastened development and retarded growth caused by thyroid feeding were similar to the effects of thyroid feeding on vertebrates, though not nearly so marked.

Romeis and von Dobkiewicz (1920) working with thyroid-fed larvae of *Calliphora vomitoria* obtained results directly opposite to those of Kunkel. Whereas Kunkel obtained accelerated metamorphosis, these investigators observed that their thyroid animals were retarded from 25 to 35 hours throughout the entire period of metamorphosis as compared with the muscle-fed controls. The thyroid-fed animals, during the early stage of larval development, were smaller than the controls, but this difference had disappeared by the time pupation occurred. In fact, the thyroid-fed pupae were slightly heavier than the controls, and the adults of the experimental group appeared to be "better fed" than the controls.

The inconsistency of results reported in

the above two papers is undoubtedly an expression of differences in experimental technique rather than of any real difference in the effect of thyroid gland feeding. The gland substance in each case was that of the calf, and the method of feeding in each was to allow the larvae to live in the tissue substance. Romeis and von Dobkiewicz used isolated larvae, necessitating the mechanical control of the moisture in the food medium (especially thyroid) and a change of the food every few days to prevent putrefaction. The resulting "better fed" adults, obtained by Romeis and von Dobkiewicz by thyroid feeding may have been due to the frequent change in food supply, since it was noted that it was necessary to renew the thyroid more often than the muscle (control) substance.

Reznitchenko (1926), studying the effect of thyroid feeding on *Drosophila melanogaster*, found that no changes were produced in the length of either larval or pupal period when the concentration of thyroid was less than 5 percent of the total ration. In concentrations of 10 percent thyroid substance there was a slight retardation in development. This latter effect was considered as a toxic reaction, rather than any specific hormonal effect. Later (1927) this same investigator confirmed his earlier work on thyroid feeding of *Drosophila* by showing that thyroidin added to a diet of potato and yeast produced no effects on the rate of development of this form. From the experience of these two studies the author concluded that thyroid was non-specific for invertebrates. In contrast to the findings of Reznitchenko are those of Alpatov (1929). In this study, the extract used was powdered hog thyroid containing 0.42 percent of iodine. It was fed to the *Drosophila* by mixing it with yeast in the proportion of 0.05 gm. thyroid to 0.50 gm. yeast; this mixture then being mixed with distilled water and

added to the food bottles at the rate of 5 drops per day during the larval period. The food bottles contained 50 gm. of plain 2 percent agar-agar. The controls were fed powdered hog muscle in the same proportion that the experimentals were fed thyroid. For the first 48 hours of the experiment, the bottles were kept at a temperature of 30°C. and thereafter at 28°C. Larvae 0-4 hours old were placed on the food, and 67 hours later they were killed and measured. Nine experiments including a total of 8000 flies were thus measured. All the experiments showed definitely that the thyroid larvae killed just before they started to leave the food and crawl up the sides of the bottle were

make a careful study of the problem from a statistical point of view, and that in this respect, his findings are of greater significance than those based on random judgment of the characters affected. The data of Alpatov are far more reliable than those of Reznitchenko, because the later investigator made no attempt to correct for differences in fly density, which, as he stated, seemed to affect rate of development more than any other factor. There was a 10 percent variation in each 24-hour observation of several control groups, so that the differences exhibited by the experimentals seemed only a natural occurrence.

Later Koller (1932) made a study of the effect of chemically pure thyroxin on cer-

TABLE 3

Larval growth of Drosophila

All larvae belonging to the third stage. Initial density, 80 larvae per bottle. (From Alpatov, W. W. 1929. Proc. Nat. Acad. Sci., Vol. 15, pp. 578-580.)

| | MEAN LENGTH (IN MM.) | STANDARD DEVIATION | COEFFICIENT OF VARIATION | N | DIFFERENCE | DIFF. P.E. DIFF. |
|--------------|-------------------------|-----------------------|--------------------------------|-----|---------------|---------------------|
| Control..... | 4.916 ± 0.007 | 0.2120 | 4.31 ± 0.10 | 400 | 0.222 ± 0.010 | 22.2 |
| Thyroid..... | 5.138 ± 0.007 | 0.2266 | 4.41 ± 0.10 | 422 | | |

significantly larger than the controls. The data from a representative experiment are given in Table 3.

The experiments in which the flies were allowed to reach maturity showed that the thyroid-fed adults were slightly smaller than the controls. These results indicated to the author that thyroid feeding had an accelerating effect only during larval development and that this fact, coupled with the fact that the experimental adults were smaller than the controls, confirmed the work of many authors on the thyroid feeding of amphibia. The conclusion was reached that substances produced by the glands of internal secretion have a universal effect on living organisms. It will be noted that Alpatov was the first to

tain characteristics of *Drosophila melanogaster*. This worker found that thyroxin had no effect on rate of metamorphosis, fecundity, sex ratio, size, or crossing-over in this form. A slight delay in egg-laying was attributed to a secondary action of the thyroxin (higher pH in the food medium). From the variations in the results of thyroid treatment of *Drosophila*, it is evident that much more carefully controlled experimentation is required to make a conclusive statement about the problem.

The work of Comas (1928) indicated that thyroid feeding of the larvae of *Chironomus thummi* K. caused an acceleration in larval growth, especially during the mid-period of development. Concomitant with the accelerated develop-

ment came an increase in size attained by the animals. Zavfel (1930) found that young or medium, later summer or fall larvae of *Chironomus clavaticrus* K. fed dried thyroid grew more rapidly than the controls, especially at the beginning of the experiment, but did not metamorphose any faster than the controls. Early summer larvae fed with thyroid extract grew very rapidly and metamorphosed 1 to 2 months earlier than the controls. The embryo development of fresh laid eggs was greatly delayed by thyroid extract, but when the eggs were returned to fresh water the embryos soon recovered from the effect and continued developing normally. The growth of larvae from thyroid treated eggs sometimes surpassed that of the controls. Muscle extracts had no stimulating effect on the midge larvae.

From these studies it is evident that, for *Chironomus* at least, the age of the larvae as well as the seasonal form must be taken into consideration in dealing with the problem. Generally speaking, thyroid extract produces an acceleration in the early growth of all larval forms, but the effect on metamorphosis and final size depends on the particular seasonal form studied.

Abderhalden (1919) observed that thyroid feeding had no noticeable effect on the rate of development of the moth, *Deilphila euphorbia*, but that the pupae and adult forms were much smaller than those fed with thymus extract. This worker stated that the extent of variations in his results made it impossible to give a final conclusion until further experimental work showed more constant effects. Romeis and von Dobkiewicz (1920) noted that their work on *Calliphora* was at variance with that of Abderhalden, but they considered that the difference in the forms used in the two experiments, together with Abderhalden's variable and incon-

clusive results easily accounted for all discrepancies.

Romeis and von Dobkiewicz (1932) and Romeis and Wüst (1932) noted that the pupae of *Papilio podalirius*, *Vanessa io*, or *Vanessa atalanta* showed little or no rise in metabolism following sterile injections of thyroxin. The hormone had no observable effect on the growth or metamorphosis of these forms.

Kopeć (1924) reported a thyroid feeding experiment on the caterpillars of *Lymantria dispar* L. The newly hatched larvae were fed on willow leaves sprayed with water (control), and on the same type of leaves sprayed with a thyroidin suspension in water. Two to four "tablettae thyreoideae" were used daily, though this gives us no indication of the relative or absolute quantity of thyroid in the total ration. The total number of thyroid chrysalids was 422; of controls 396. It was observed that the thyroid extract did not cause any distinct changes in the duration of larval or pupal periods. The only effect noted was a diminution of weight in the thyroid-fed chrysalids, as compared with controls. These results are similar to those obtained by Abderhalden (above), with *Deilphila euphorbia*, and furthermore are based on a statistical study of the data. The conclusions, however, cannot be taken too seriously until the work is confirmed by check experiments, in which known quantities of thyroid are fed, and until the effects of widely varying concentrations of the extract on the organisms have been determined.

Fleischmann (1929) studied the effect of parenteral injections of a 1:10,000 concentration of thyroxin solution on the larvae of *Lymantria dispar*. The controls were injected with equal quantities of a normal salt solution, and some were left uninjected. No effect was observed in the length of larval or pupal period of the

experimental animals as compared with the controls. Further, there were no differences in either weight, color, or pattern among the experimental and control groups. These findings were based on the performances of 61 experimental and 44 control animals, and were cited as confirming the work of Romeis (*et al.*) noted above.

Terao and Wakamori (1924) criticized the work of Abderhalden (1919) and Romeis and von Dobkiewicz (1920) by suggesting that the negative results of the latter two investigations were due to the fact that the observations were based on the first generation only, and that if the observations had been carried to a second generation, certain effects may have been noted. In the experiments of Terao and Wakamori (1931), larvae of the silk-worm *Bombyx mori* L. were fed on mulberry leaves over which had been sprinkled a commercial thyroid powder. The thyroid varied from 1/50 to 1/400 of the weight of the food. It was noted that the experimental animals did not eat their food as readily as the controls, possibly because of an unpleasant odor or taste of the thyroid substance. Throughout the entire life, there was no acceleration observed in the rate of development as a result of thyroid feeding. On the contrary, the more of the gland substance fed, the slower the animals developed. The adults of the experimental group were smaller than the controls, and generally in indirect proportion to the quantity of the thyroid given. In a second generation experiment, larvae hatched from the eggs of those parents which had, as larvae, been fed thyroid extract were reared together with the second generation of the control under the same (control) conditions. From the beginning of the larval period to the end of the third instar, both groups behaved the same so far as the speed of metamor-

phosis was concerned. From the fourth instar on, the progeny of the thyroid-fed parents passed through their developmental stages considerably earlier than the control progeny, the average difference being 12 hours at the commencement of moulting, and 24 hours at the end of the pupal period. The experimental progeny were smaller than the controls when hatched because they came from smaller eggs laid by the thyroid-fed animals. This difference, however, decreased as development proceeded, and at the end of the second instar, the opposite was the case, i.e., the experimental progeny were larger than the controls. The experimental group kept supremacy over the controls in size until the beginning of the fifth instar, when the former became abruptly smaller than the latter. Consequently the resulting pupae, cocoons, and adults of the experimental progeny were smaller than the controls. In spite of the smaller size, however, they laid more eggs and produced more silk than the controls. Later (1931) these investigators confirmed their earlier work on the second generation effect of thyroid feeding on *Bombyx*, and concluded that the action of the thyroid would, in time, be shown throughout the animal kingdom, and that the gland substance would be shown to be specific only in its degree of activity in the different forms.

Kahn (1921) studied the effects of thyroid feeding on the larvae of *Corethra plumicornis*, *Ecdyurus forcipula*, and *Tenebrio molitor*. Other than a change in the color of the pupae (lighter than controls) no effect of thyroid feeding was observed in these forms. The rates of metamorphosis and growth were identical in the control and experimental groups. The conclusion was reached that the changes in growth and development of vertebrates due to thyroid feeding do not appear in the inverte-

brates because they are not affected by the vertebrate hormone. A conclusion very similar to this was reached by Hahn (1929) based on his experiments with *Vanessa io* and *Tenebrio molitor*. The larvae of *Vanessa* were fed on nettle leaves sprinkled with thyroid extract. The controls were fed on similar leaves sprinkled with an extract of ox heart. There was a slight diminution in the rate of development of the thyroid-fed animals, with a slight increase in body weight. These differences were so small they were not considered due to any specific thyroid effect. For *Tenebrio* no effect at all was observed in rate of development or growth as a result of feeding a concentration of 1 part thyroid to 3 parts meal. The experimental animals compared favorably with the controls (extract of ox heart in meal), in color, sexual development, and sex ratio. Here again the conclusion was made that thyroid is non-specific for invertebrates.

SUMMARY

It is clear that invertebrate organisms (Protozoa and insects, at least) although not possessing any thyroid structure, will, in some cases, respond to the action of the thyroid hormone. Further it is evident that, when there is a response, the reaction is quite similar to that seen in vertebrates; an increased rate of metabolic processes. The abundance of negative results reported above, however, puts us in no better position than was Koller (1929) when he said "The feeding of invertebrate animals with vertebrate hormones has not yet led to definite and unambiguous conclusions."

One obvious reason for the indefinite and ambiguous conclusions, as mentioned previously, is that no systematic attempt has

been made up to the present to determine the influence of a logically planned series of concentrations of thyroid substance on an invertebrate organism. From the literature, it is difficult to determine the exact dosage, either absolute or relative to the total ration, that was fed in the great majority of experiments that have been reported. Further, it is evident that in most cases only one or at most a very few different concentrations were used. If a variety of concentrations had been used, and careful statistical comparisons had been made, many of the negative results obtained by earlier investigators, working with only *one* concentration, would undoubtedly have been found to be due to the toxic effect of too heavy a concentration, or to the lack of effect from too light a concentration. In investigations such as those reviewed it is essential to determine at least (1) the optimal concentration for any particular effect; (2) the minimal concentration for producing any effect at all, and if possible (3) the lethal concentration.

Another question that needs considerable experimental evidence for its solution is that of the possible transfer of the thyroid effect to a second generation without thyroid feeding. This phenomenon has been asserted and denied in the literature, though with none too conclusive evidence on either side.

An account of the experimental work by which the writer has attempted to solve some of the above questions will appear in a later publication.

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THE WATER BALANCE IN MARINE MAMMALS

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THE problem of the maintenance of the water balance in marine mammals, though it has received some attention, has never been adequately discussed. It is the purpose of this paper to bring together such limited and scattered data as are to be found in the literature with a view to providing the basis for a more complete study of the problem. Kellogg ('38) has recently reviewed the general structural adaptations of whales, and Irving ('39), the problems of respiration in diving animals. Since data are available only for Cetaceans and Pinnipedes, these alone will be discussed, the herbivorous Sirenia not being considered.

In common with other marine forms, the conditions of life of marine mammals are relatively very constant, seasonal variations in temperature and food supply are largely compensated for by migrations.

FOOD AND WATER INTAKE

Most of the food of the Cetaceans consists of animals isotonic with sea-water; baleen whales (Mystacoceti; genera mentioned, *Balaenoptera*, *Balaena*, and *Megaptera*) feed exclusively on the plankton and small crustaceans, as is well known (e.g. Norman and Fraser, '37, and Mackintosh and Wheeler, '29). Much of the food of toothed whales (Odontoceti; genera mentioned; *Delphinapterus*, *Globiocephalus*, *Phocoena*, *Physeter*, and *Tursiops*) is made up of cephalopods, especially squid and cuttlefish, the body fluids of which are also

practically isotonic with sea-water. Certainly some Pinnipedes feed largely on crustaceans, Portier ('10), for instance, reports five individuals belonging to two species (*Phoca barbata* and *P. foetida*) the stomachs of which were filled with crustaceans. On the basis of food, it is therefore not possible to differentiate the two types of whale, nor even the seals, for the present purpose.

Several observations indicate that marine mammals do not ordinarily drink sea water (e.g. Mackintosh and Wheeler, '29, Laurie '33). Portier ('10) reports that even the seals referred to above, which have access to fresh water in the form of ice, were not observed to make use of it. Irving *et al.* ('35) report: "None of the seals were observed drinking sea water, but four seals shipped to Toronto in a warm express tank car drank fresh water greedily as soon as a clean supply was available." Suzuki ("Sudzuki" in earlier papers), ('24) observed that whales often drank after they had been wounded. More positive evidence that they do not drink, and that only minimal amounts of sea water are ingested with the food comes from observations of the stomach contents and analyses of the feces. Geiling and Robbins (personal communication), for example, report that the stomachs of numerous white whales (*Delphinapterus leucas*) which they examined, many containing much food, were essentially "dry." Smith ('36) found only traces of Mg and SO₄ in the intestinal residua of the com-

mon harbor seal (*Phoca vitulina*) and correspondingly low amounts in the urine, indicating minimal sea water ingestion. Irving *et al.* ('35) also report low chlorides in the feces. These mammals must therefore depend entirely upon their food as a source of water, unless special mechanisms be assumed.

The water requirements of marine mammals are lower than those of terrestrial mammals as Irving *et al.* ('35) have pointed out. Because of the low and constant temperature of their surroundings, and because of the insulating layer of blubber, no water is needed or used for cooling by evaporation; indeed, they have no sweat glands. Thus the only water outgo is in the urine, the feces, and the exhaled air.

CONSTITUENTS OF BODY FLUIDS

Tables 1 and 2 summarize the relevant data contained in the literature. They include the principal inorganic constituents and the freezing point depressions of various body fluids and of the urine; the total nitrogen for the body fluids, and the urea for the urines. Several other animals and sea water are included for comparison. Most of the data have been reduced to two significant figures, and many have been recalculated to comparable units. Besides the more complete analyses included in the tables, there are the following fragmentary determinations: Two "Seebar" (Ursine seal, *Otoca alascanus* (?)) whole bloods, Suzuki '25a, $\Delta = 0.70-0.72^\circ\text{C}$; total N, 39-40 g/l; Cl, 96 milli-Moles/l. Blood sera: 20 samples of finback whale (*Balaenoptera physalus*), Laurie ('33), Cl, 110-120 m-M/l; the following sera freezing point depressions—one dolphin (*Tursiops tursio*), Jolyet ('02), 0.83°C ; one porpoise (*Phocoena communis*), Rodier ('99), 0.74°C ; Portier ('07), two *Phoca barbata*, 0.64 and 0.66°C , and three *P. foetida*, 0.66,

0.68, and 0.72°C . For the biles of the same seals (no determination for the third *P. foetida*) Portier reports 0.63, 0.66, and 0.71°C . For the pericardial fluid of the same dolphin referred to above, Jolyet gives a Δ of 0.80°C , and for the cephalo-rachidien, fluid, 0.81°C . Laurie ('33) lists 22 chloride determinations on blue whale amniotic fluid, distributed from 14 to 120 m-M/l, half between 20 and 51. Measurements of blood specific gravities are scarce for whole bloods, Suzuki ('24) reports 1.06 to 1.08; Myers ('20), 1.04 to 1.06. Suzuki ('24) gives 1.03 for the sera of seven whales. Portier ('07) reports for blue whale aqueous humour $\Delta = 0.70$ and 0.71°C .

Also the following fragmentary determinations on urines: Morimura ('25), seven Sei whales (*Balaenoptera borealis*) had freezing point depressions from 1.8-2.5; average, 2.1°C . Ichimi *et al.* ('25) give 570 m-M/l urea for one finback whale. Portier ('07) reports Δ 's of 0.73 and 4.5°C for two seals. Laurie ('33) determined the chloride concentrations of 45 blue whale (*Balaenoptera sibaldii*) urines; these range from 170 to 450 m-M/l with many at 340-370. Irving's eight chloride determinations on seal urine range from 82 to 260 m-M/l. Two samples of finback whale urine tested by the author gave freezing point depressions of 3.1 and 1.9°C , with corresponding chlorides of 850 and 210 m-M/l. Similar determinations on the urine of a white whale gave 3.2°C and 75 m-M/l respectively. The specific gravities of the urines on which this measurement has been made are typically close to 1.03, with occasional values of 1.04, and one of 1.05. The pH values are about 6.

Good samples of whale blood are difficult to obtain, since the chances of contamination by sea water are many. The greatest difficulty lies in the fact that even

TABLE 1
Body fluids

| SAMPLE AND NUMBER OF DETERMINATIONS | SOURCE | $\Delta^{\circ}\text{C}$ | MILLI-MOLES/L | | | | | | |
|-------------------------------------|----------------|--------------------------|---------------|---------|---------|---------|---------|---------|---------------|
| | | | Total N g/l | Na | K | Ca | Mg | Cl | SO_4 |
| <i>Whole blood</i> | | | | | | | | | |
| 4 finback whales | Okahara ('25) | — | 26-28 | 140-150 | 56-59 | 1.4-1.9 | 1.9-2.7 | 140 | .24 |
| 1 Sei whale | Suzuki ('24) | 0.66-0.72 | — | 130 | 41 | 2.7 | 0.8 | 100 | — |
| 1 right whale ^a | Macallum ('26) | — | — | 74 | 49 | 1.8 | 2.1 | 76 | — |
| 1 humpback whale ^b | Myers ('20) | — | 22 | — | — | 2.7 | — | 100 | — |
| 2 sperm whales ^c | Suzuki ('24) | 0.66-0.72 | — | 140 | 44-49 | 1.6 | 1.1-1.2 | 100 | — |
| 1 sperm whale | Myers ('20) | — | 35 | — | — | 2.5 | — | 87 | — |
| 1 porpoise | Suzuki ('24) | — | — | — | — | 4.2 | 2.3 | 99 | — |
| <i>Serum</i> | | | | | | | | | |
| Man | Eichelberger | 0.54-0.59 | 11-14 | 135-145 | 3.5-5.0 | 2.3-2.8 | 0.5-1.0 | 99-105 | 2.3 |
| Dog | Hastings ('37) | 0.57 | 9 | 142 | 3.7 | 2.5 | — | 109 | — |
| 1 sperm whale | Suzuki ('24) | 0.66-0.72 | — | 170 | 2.6 | 0.2 | 2.3 | 120 | — |
| Teleost-Pollack | Macallum ('26) | 1.04 | — | 180 | 4.6 | 3.2 | 2.5 | 160 | — |
| <i>Limulus</i> | Macallum ('26) | 2.04 | — | 390 | 13 | 9.0 | 41 | 480 | 13 |
| <i>Pericardial fluid</i> | | | | | | | | | |
| ? Sei whales | Suzuki ('21) | 0.69-0.70 | 2.9-3.2 | 160 | 15-18 | 2.0 | 0.5 | 110-120 | 5-6 |
| <i>Amniotic fluid</i> | | | | | | | | | |
| 1 m sperm foetus | Suzuki ('25c) | 0.58 | 2.2 | 28 | 1.3 | 8.2 | 3.8 | 34 | 5.6 |
| 4 m Sei foetus | Takata ('21) | 0.68 | 1.7 | 61 | 6.4 | 0.8 | 0.3 | 34 | 14 |
| <i>Peritoneal fluid</i> | | | | | | | | | |
| 1 finback whale | Fuse ('25) | 0.70 | 5.4 | 140 | 7.7 | 2.5 | 2.5 | 140 | 2.1 |
| <i>Sea water</i> | Dittmar ('84) | 2.3 | — | 490 | 9.8 | 10 | 54 | 540 | 27 |

^a *Balaena mysticetus*. Data were given as g/100g; they have been recalculated assuming a Sp.gr. of 1.06.^b *Megaptera nodosa*.^c *Physeter macrocephalus*.

TABLE 2
Urine

| SAMPLE AND NUMBER OF DETERMINATIONS | SOURCE | Δ°C | MILLI-MOLES/L | | | | | | | |
|-------------------------------------|-----------------------|-----------|---------------|---------|-------|---------|---------|---------|-----------------|-----------------|
| | | | Urea | Na | K | Ca | Mg | Cl | SO ₄ | PO ₄ |
| Man | Cushny ('26) | 1.8 | 380 | 150 | 31 | 3 | 4 | 170 | 18 | 25 |
| 1 Sei whale | Morimoto ('21) | 2.49 | 400 | 330 | 54 | 5 | — | 370 | 38 | 21 |
| 4 Sei whales | Ichimi ('25) | — | 420-650 | — | — | — | — | 160-370 | 33-43 | 23-27 |
| 4 Sei whales | Schmidt-Nielsen ('21) | 2.46(1) | 380-530 | 240-290 | 36-82 | 0.3-2 | 1.6-4.1 | 180-370 | 36-45 | 16-41 |
| 5 finback whales | Schmidt-Nielsen ('31) | — | 250-420 | 230-330 | 56-72 | 1.8-5.3 | 2.5-5.8 | 160-370 | — | 7.1-41 |
| 2 finback whales | Schmidt-Nielsen ('21) | — | 380-430 | 270 | 67 | 3.3 | 6.6 | 250-390 | 31-40 | 7.9-41 |
| 1 blue whale | Morimoto ('21) | 2.50 | 420 | — | — | — | — | 340 | (49) | 61 |
| 1 pilot whale ^a | Suzuki ('25b) | 2.01 | 480 | — | — | — | — | 180 | — | — |
| 2 porpoise (sp. ?) | Suzuki ('25b) | 2.28-3.41 | 480-840 | — | — | 7.0 | 10 | 170-240 | — | — |
| 1 white whale | Fetcher | 3.23 | 570 | — | — | 18 | 21 | 39 | 5.9 | 34 |
| Seal | Smith ('36) | 1.72-3.99 | 120-1050 | — | — | 1.3-5.5 | 0.8-30 | 200-420 | 6-97 | 24-200 |

^a *Glaciophonus molas*.

under the best conditions hitherto available several hours have elapsed from the time of death of the animal until the time of sampling. This delay permits diffusion of sea water from lungs or intestine into the blood, or from the wound (the animals bleed freely when wounded). Furthermore, because of the heavy insulating layer, the temperature of the whale drops very slowly indeed, so that enzyme and bacterial action may change the samples markedly. It is for this reason that Portier ('07) chose the aqueous humor of the blue whale for his osmotic pressure determinations, since the temperature of this fluid would fall very quickly, and the sclera is certainly completely impermeable to the sea salts. Other body fluids are probably less subject to contamination by sea water than the blood; analyses made on the smaller Cetaceans—the porpoises and dolphins—as well as those of seals shot on ice floes are certainly more reliable; these may be used as a basis for comparison of blood samples of the large whales. It is on this basis that the data are included in the tables and the discussion to follow.

In the opinion of the author Portier's freezing point measurements of seal blood and bile, and of the aqueous humor of the blue whale are reliable; the latter for the reasons given above, and the former because the animals were not in contact with the sea, at the time of death or subsequently. Jolyet's three similar measurements on the dolphin, high as they are, should also be reliable for the samples were taken from a living animal in the air. Suzuki's ('24) analyses of Ursine seal blood are also probably good, since the animals were caught in nets. If these results be taken as approximately correct, the rest of the analyses listed are concordant; and hence these too may be included in the discussion.

The most striking conclusion to be drawn from Table I is that the osmotic pressures are definitely higher than those of terrestrial mammals; a value of 0.69°C may be taken as a first approximation; the variations will be discussed below. Whole blood Na, Ca, and Cl are distinctly higher in marine mammals; on the basis of the one serum analysis available the concentration of NaCl in the cells appears to be nearly the same as in the plasma. The Na and Cl in this one serum analysis appear a little higher than normally found in land mammals, which is supported by Laurie's 20 Cl analyses; it is not prudent, however, to attempt to draw too many conclusions from this one sample. Macallum's whole blood analysis is in sharp contrast to the others with respect to the Na and Cl. He gives no information concerning his method of sampling but the analysis is included because it is evident, especially from the K and Mg concentrations, that it was neither contaminated with sea water, nor diluted with fresh water.

The freezing point depressions of the urines vary from within the human range to well outside, and the same may be said for the inorganic constituents; but the urea is well within normal mammalian range, since the carnivores can secrete up to 2500 m-M/l. The total salt concentrations range from about 16 to about 32 g/l. The sample analyzed by the author is very different from the others, but the low chloride was checked independently of the author's several determinations. It should be noted that most of the samples were collected following unusual activity of the animal.

WATER BALANCE

Both Irving and Smith have concluded from data on common harbor seal urines and estimates of water requirements that

sufficient water, endogenous and metabolic, is provided by their food to permit of a urine secretion similar to that of land mammals. However, they reached this conclusion on the basis of a teleost (herring) diet, on which this seal usually feeds. Smith gives very complete data for the urine of a harbor seal following a meal of macerated clams, which he fed (by stomach tube, for the animal would not eat them) in order to determine the source of the creatinuria he observed. He lists (besides urea, ammonia, creatine, and creatinine) the important inorganic constituents and the rate of urine secretion at approximately hourly intervals for ten hours after the meal. It is possible to integrate these data and calculate the total salt and water output for this period, and to correlate this with the input from the clams, taking into account metabolic water and water requirements. These calculations are summarized in Table 3.

The pertinent data given are PO_4 , Cl, SO_4 , Ca, and Mg concentrations, and rate of urine formation, at hourly intervals beginning three hours after the meal. The Na and K may be approximated by the difference in milliequivalents of anions (assuming an effective valence of 1.5 for PO_4) and cations reported; and the concentrations of the separate ions estimated on the assumption that the ratio Na/K in grams is 2.5, which is close to a number of the urines of Table 2. The total salt concentration at hourly intervals is thus obtained, whence, by graphical integration, the total salt and total water secreted in 10 hours.

Smith's data from the herring diet are not complete enough to allow of sufficiently accurate corresponding calculations, but he estimates that they check Irving's figures; the latter are used in Table 3, except that Irving's figure of 1 per cent total salt for the herring is replaced with 1.3 per cent, and his results recalculated on that basis. Oyster is used in these calculations instead of clam, no calorific data being readily available for clam; any differences will be negligible for these calculations, which, after all,

are only first approximations. No corrections are made for the low fecal salts. The data for herring are based on the whole fish; those for oyster and lobster (included for comparison) on the edible portion. The calorific data, all given in large calories, are from Sherman '37). The initials indicate the source of data or calculations as being either from Irving (L.I.) or Smith (H.S.).

In this particular case the seal, accustomed to a teleost diet, was unable to take care of the high salt concentration of the mollusk. The conclusion that the kidney must do considerably more work on a diet similar to that of the whale's is obvious. Estimates of the work required of the kidney based on the data of Tables 1 and 2 show the same result; namely, if in the "normal" mammal the increase in concentration of urea from the blood to urine be from 4 to 400 m-M/l, of salts (as NaCl) from 310 to 600 m-M/l, and of osmotic pressure 0.58 to 1.9°C; and in the marine mammal, of urea from 11 to 500 m-M/l, of salts from 370 to 1000 and of osmotic pressure from 0.69 to 2.9°C; then the work done by the "normal" kidney is 1.8 Cal/liter of urine, and that by the marine kidney is 2.5 Cal/liter of urine, or 40 per cent more work. The higher osmotic pressure of the marine mammalian blood saves the kidney some 0.4 Cal/l, or 16 per cent.

From the data presented, and from the above considerations, it is evident that the marine mammals are capable of dealing with salt concentrations outside of the normal range for land mammals. It may be assumed that the high osmotic pressure of the body fluids is connected with this problem of salt elimination. Portier ('10) suggested on the basis of the differences of osmotic pressure he observed in individual seals, and in marine palmipedes (six *Fulmarus glacialis*, Δ 's from 0.63 to 0.69, average 0.66°C), that

the osmotic pressure of the blood varied periodically, becoming high at the time of absorption of the meal, falling to a lower value subsequently. It is not possible to evaluate this hypothesis without further

(Gilman ('33 *et seq.*) and his co-workers, however, have obtained variations, lasting several hours, of 10-20 per cent in blood osmotic pressures, by injection of hypertonic solutions in various animals.)

TABLE 3
Salt balance estimates

| | $\frac{1}{2} \text{O}_2$ | $\frac{\text{Cal}}{\text{g}}$ | OYSTER | | | | HERRING (L. I.) | | | | LOBSTER | | | |
|------------------------|--------------------------|-------------------------------|--------------|------------|----------------------------|----------------------------|-----------------|------------|----------------------------|----------------------------|--------------|------------|----------------------------|----------------------------|
| | | | g (per cent) | g/1000 Cal | g met. water per 1000 Cal* | 1-O ₂ /1000 Cal | g (per cent) | g/1000 Cal | g met. water per 1000 Cal* | 1-O ₂ /1000 Cal | g (per cent) | g/1000 Cal | g met. water per 1000 Cal* | 1-O ₂ /1000 Cal |
| Protein..... | 4.6 | 4 | 6.2 | 124 | 63 | 110 | 11.2 | 140 | 71 | — | 16.4 | 197 | 100 | 170 |
| Fat..... | 4.7 | 9 | 1.2 | 24 | 25 | 45 | 3.9 | 49 | 50 | — | 1.8 | 22 | 24 | 42 |
| Carbohydrate... | 5.0 | 4 | 3.7 | 74 | 41 | 59 | — | — | — | — | 0.4 | 5 | 3 | 4 |
| Salts..... | — | — | 2.9 | 58 | — | — | 1.3 | 16 | — | — | 2.9 | 35 | — | — |
| Water..... | — | — | 85 | 1700 | — | — | 80 | 1000 | — | — | 77 | 920 | — | — |
| Totals (Rounded)... | | | | 2000 | 130 | 210 | | 1300 | 120 | 240 | | 1200 | 130 | 220 |

* For protein: $g \times 0.51$ (corr. for urea) Newburgh ('30).

For fat: $[(1-\text{O}_2) (1 - R.Q.) (2 \times 18/22.4)] [1 + 0.12]$.

For carbohydrate: $g \text{ starch} \times 0.56$.

| | 1000 CAL | OYSTER | HERRING | LOBSTER |
|--|----------|--------|---------|---------|
| Total water available..... | | 1800 g | 1100 g | 1100 g |
| Water to saturate air required for metabolism from 15 to 35°C (6 per cent inhaled air removed (L.I.))..... | | 100 g | 110 g | 100 g |
| Water for feces (L.I.)..... | | 200 g | 200 g | 200 g |
| Water available for urine..... | | 1500 g | 800 g | 800 g |
| Calc. average urinary salt conc. (g. salt/1000 cal. ÷ water for urine)..... | | 39 g/l | 20 g/l | 44 g/l |
| Salt secreted in 10 hours (H.S.)..... | | 33 g | — | — |
| Water secreted in 10 hours (H.S.)..... | | 1100 g | — | — |
| Average urinary salt conc. 10 hours (H.S.)..... | | 30 g/l | — | — |
| Salt residue $[58 - (1500 \times 30)/1000]$ | | 13 g | — | — |
| Calc. dehydration of 30 kg animal from salt residue $(13/.03 \times$ $22,500)$ | | 1.9% | — | — |
| Calc. body fluid osmotic pressure increase, 30 kg animal $\left(\frac{13}{58.5 \times 22.5} \times 1.86 \right)$ | | 0.02°C | — | — |

experimental work, except to observe that the freezing point depressions listed in Table I show considerable variation, and that in the light of other mammalian experience such variations are improbable.

This hypothesis contributes little to the problem at hand, for it refers primarily to the rate of renal secretion relative to the rate of intestinal absorption, and only secondarily to the increased urine con-

centration possible with higher blood osmotic pressure.

It will be seen that there is a discrepancy between the range of normal variation of the total urinary salt concentration in the analyses tabulated (16 to 32 g/l, with many at 29 g/l) and the estimate of average total urinary salt concentration following a meal of invertebrates (39 or 44 g/l). One would expect that many of the urines would approximate this figure if the kidney alone were responsible for removal of all ingested salt, and if no water were available other than that from the food. Actually few approach, and only two complete analyses (Smith, for the clam diet, 36 and 37 g/l) even reach it, whereas a great many are well below. It would seem impossible on the above assumptions for baleen whales, at least, to afford the comparatively dilute urines reported; except after excessive renal work, for which no evidence is to be found. It is hardly probable that the discrepancy is coincidental, since so many complete and partial analyses are available, nor does it seem possible that the salt and water estimates of the food could be so greatly in error. If these premises be accepted, it then becomes necessary to assume some special mechanism for the elimination of salts, or for provision of relatively salt free water, or both, the nature of which must be a matter of speculation at present. One is tempted to suspect modification of the buccal glands, since cutaneous glands are absent. The Cetaceans apparently have no salivary glands (Schulte, p. 432; Sonntag, '22; Robbins, personal communication) but do have glands in the tongue "more numerous than any other *Mammalia*" (Sonntag, '22). No histological account of these has been found. Perhaps the fact that Cetaceans can survive only a few hours out of water is related to this

problem, as well as to that of heat regulation.

CONCLUSION

In conclusion, it now appears reasonably certain that those marine mammals for which data are available have undergone not only morphological adaptations, but adaptations of their cellular physiology, and possibly modifications of their special physiology to compensate for the medium in which they live. The higher, possibly fluctuating, osmotic pressure of the body fluids, and the greater capacity of the kidney, are apparently merely extensions of normal mammalian functions. Only further experimental work can decide to what extent this is true for any special mechanism for salt elimination or water intake.

SUMMARY

The literature relating to water balance is reviewed. The available data indicate a blood freezing point depression of about 0.69°C . Whole blood Na, Ca, and Cl are somewhat higher than in land mammals. Most urine total salt concentrations are in the range of 16 to 32 g/l with many at 29 g/l; urea concentrations are "normal." Estimates of urine salt concentrations are made from the composition of vertebrate and invertebrate foods, assuming no water intake other than that in the food. It is concluded that those marine mammals which subsist largely on vertebrates have no special salt clearance problem; whereas those living on invertebrates probably do have a special mechanism for the reduction of urinary salt concentration.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland U. S. A.

CHEMISTRY AND SEX

Being a review of the second edition of *Sex and Internal Secretions*. Edited by Edgar Allen, C. H. Danforth, and E. A. Doisy. Baltimore (Williams & Wilkins Co.), 1939. Pp. xxxvi + 1346. \$12.00. By Gregory Pincus, *The Biological Laboratories, Clark University, Worcester, Massachusetts*.

The publication in 1922 of the last edition of F. H. A. Marshall's classical *Physiology of Reproduction* marked the end of an era of investigation that may well be termed the pre-chemical. We are now in the boiling midst of the chemical era, initiated decisively in 1923 with Allen and Doisy's demonstration of a water-insoluble oestrogenic ovarian follicular hormone, given impetus by the discovery of a ready source of such substance in large amount in pregnancy urine, further accelerated in 1927 by McGee's preparation of a lipoid androgen fraction of testis tissue and the finding of similar material in male urine, and carried into complex new fields by the simultaneous publication in 1927 of studies by Smith and Engel and by Aschheim and Zondek of anterior pituitary gonadotropic principles. As a result of these initial accelerations organic chemists have produced, with increasing velocity, chemically pure steroids and related compounds that are (or mimic the activities of) the effective hormones of the gonads. In addition to the gonadotropic there have been prepared pituitary products that are adrenotropic, thyrotropic, mammatropic,

lactogenic, diabetogenic, ketogenic, and so on. The physiologists and experimental morphologists have employed the chemical preparations for the investigation not only of specific hormonal effects but also for new approaches to, among a host of others, such varied problems as the nature of sex-determination in vertebrates, of parturition in mammals, of genital pathology in man.

In this second edition of *Sex and Internal Secretions* nine zoölogists, seven anatomists, seven biochemists, a geneticist, a cytologist, a psychologist, and a gynecologist attempt in some 1300 pages to present the genetic and endocrine basis of our knowledge of sex function. Even with this formidable authorship an exhaustive exposition is disclaimed. The book is divided into five sections concerned with: (A) the biological basis of sex; (B) the physiology of the sex glands, germ cells, and accessory organs; (C) the biochemistry and bioassay of gonadal hormones; (D) the hypophysis and the gonadotropic hormones of blood and urine in relation to the reproductive system; (E) the additional factors in sex functions and endocrine applications in man.

The presentation of the subject matter is of course bound to differ from chapter to chapter with so varied an authorship, but the general accomplishment of the book may be appraised by stating at once that an intensive reading will yield an extraordinary return. The biology of sex and its manifestation, particularly in the

vertebrates, is thoroughly and soundly presented. The editors have done a first-rate job of assembling and coördinating the various chapters into an orderly whole. It is obvious that their task was an extremely difficult one. Even casual perusal reveals that certain chapters were completed late in 1938 whereas others were completed in 1937. This has necessitated addenda to a number of chapters.

The book opens with a short introductory chapter by Dr. Frank Lillie concerned chiefly with establishing the differences between sex determination and sex differentiation. Dr. Lillie insists that "the sex of the gametes and sex in bodily structure or expression are two radically different things." Control of sex determination is "chromosomal." Sex differentiation is either nuclear (as in insects) or "taken over by intracellular agents" such as hormones in the vertebrates. Exception might be taken to the notion of absolute chromosomal control of sex differentiation in insects on the basis of the demonstration of Ephrussi, Beadle *et al.* that extracellular agents are responsible for eye differentiation in *Drosophila*. Presumably in development the gonads and accessory structures may also be influenced by similar substances. Until we are more completely informed of the physiological mechanisms involved in early embryology absolute distinctions can serve only as convenient guides. For this reason Castle's idea of sexuality as plus and minus variations in a single scale of graduations may have validity in spite of Lillie's rejection of it for his dichotomous scheme.

The cytological and genetic basis of sex is presented posthumously by Dr. Bridges. In this chapter the author's ideas of the rôle of genetic balance in sex determination are clearly elaborated and recent work in insects particularly is brought into line with his theories. As a result there is a somewhat cavalier treatment of Goldschmidt's work. A rather single-minded absorption with his own hypotheses led Bridges to present certain objections, particularly to Goldschmidt's "time law of intersexuality," at the same time ignoring Goldschmidt's factual and theoretical refutations of these criticisms.

The two succeeding chapters by Dr. Willier and Dr. Witschi are, in the opinion of this reviewer, superlative presentations of the facts of the embryonic development, of sex and its experimental modification. Witschi's general theory that "masculinization and feminization depend directly or indirectly on the relative activity of gonadal medulla or cortex and their related tissues" is supported by a beautiful array of evidence.

Dr. Domm in Chapter V discusses modifications in sex and secondary characteristics in birds. In accounting for certain primary modifications the author declares that the gonadal cortex produces oestrogens; the medulla, androgens. This is treading on dangerous ground since either gonad *may* produce both. Males and females excrete both, and castrates have been shown to excrete both. (Marker has recently isolated androsterone, dehydro-androsterone and oestrone from steer's urine, Englehart and Callow and Parkes demonstrated oestrogen in cortical extracts.) It also is to be regretted that, in an otherwise rather complete exposition of the factors governing gonad development in birds, Benoit's extraordinary demonstration of the effect of light upon the duck pituitary is omitted. Domm's account of the control of plumage dimorphism is an extremely competent presentation of the modern view of this classical problem.

A summarizing chapter by Dr. Danforth concludes the first section of the book. It is concerned broadly with the origin and evolution of sex, and illustrates with apt examples the balance between genic and endocrine factors. This thoughtful disquisition on the development of the gene-hormone dichotomy tempts the reviewer to elaborate upon the putative reality of extracellular and intracellular hormones. Resisting temptation, one may, nonetheless, wonder about the statement that "In general it seems more illuminating to think of the cells as utilizing the hormones rather than of the hormones as actively stimulating the cells." The statement itself may be a tautology.

The second section begins with Dr. Moore's chapter on the biology of the

testis. It presents a very clear exposition of the spermatogenetic and endocrine functions of the testis and the physiological control of both. The author is at a loss to explain the widely conflicting papers on the effects of castration on learning ability in rats. One possible explanation may be that congenital (genetic) differences between strains are involved. The matter is of some consequence in view of recent indications that mental disease and androgen metabolism may be related. An excellent critique of various pseudo-scientific theories of rejuvenation distinguishes this chapter.

Drs. E. Allen, Hisaw and Gardner follow with a long, informative, laconic chapter on ovarian function. Over half of the chapter is devoted to a discussion of periodicity in the female. In evolving a theoretical explanation of the control of the oestrus cycle, the authors give scant consideration to two extremely relevant experimental findings. The first is the demonstration (by Robson and Westman and Jacobsohn) that, in the absence of the pituitary, oestrogen alone maintains functional corpora lutea; the second is the possibility of an endogenous uterine periodicity as indicated by Zuckerman and Hauptstein and Bühler. There is, indeed, a sentence to the effect that the latter authors "report experimental evidence" on the rôle of the uterus in regulating the oestrus cycle, but the actual evidence is not cited. Again, in offering a probable explanation of menstruation, the authors give no consideration to the evidence of Smith and Smith that a "positive precipitating factor" may be involved. Finally, in considering the evidence from studies on oestrogen excretion, the authors nowhere mention that excretion studies which do not involve the freeing of "bound" oestrogen are of negligible significance and that furthermore a large number of such studies are thereby vitiated. The rôle of known detoxicating mechanisms is not recognized in a description of the rapid disappearance of injected oestrogen. Excellent descriptions of the qualitative effects of the ovarian hormones on various end-organs occupy a large section of this chapter. The discussion of atypical growths following oestrogen

administration is especially good. A concluding section is devoted to evolutionary trends in ovarian function.

The chapter on ovulation, fertilization and the transport of eggs and sperm by Dr. Hartman is written with gusto and sparkle. It reads well and tells all worth knowing.

Dr. Newton's brief chapter on endocrine function in pregnancy is notable for its detached critical outlook. Its brevity is largely due to a paucity of informative physiological data on this most important phase of the reproductive cycle.

This second section of the book concludes with a discussion of the mammary glands by Dr. Turner. A brief statement of fact about the nature of mammary development in ontogeny and during reproductive function is followed by a full presentation of fact about the endocrine control of this development. The latter is marred by the citation of conflicting evidence on the rôle of the hormones. Little or no attempt is made to evaluate often contradictory findings. This may be due in part to the lack of comparable quantitative measurements in the original papers.

The third section of the book contains chapters on the biochemistry of the androgens, oestrogens, and progesterin, by Drs. Koch, Doisy, and W. Allen, respectively. All three are succinct, capable presentations. Dr. Doisy's chapter, completed in 1937, presents more recent information rather sketchily in an addendum and in footnotes. Thus the text cites the conversion of ergosterol to oestrone by Marker *et al.* and recent authoritative criticism of this putative conversion is too briefly given in a footnote. Again, the lengthy series of papers by Marker and his colleagues on oestrogen excretion and their discussion of the biochemical origin of the hormones is not mentioned.

Dr. Gustavson's chapter on the assay of androgens and oestrogens is rather summary and overweighted by the author's personal experience. Various valuable assay methods are not presented, such as Astwood's excellent short method (mentioned by Allen, Hisaw, and Gardner earlier in the book) and other techniques involving the use of the uterine weight

in immature rats and mice. The colorimetric determination of urinary androgen as developed by Oesting, Callow and others is completely ignored. Even in citing the conventional Allen-Doisy test for oestrogen the author gives no express statement of its limits of accuracy. In fact, the statistical considerations which must validate any assay procedure are referred to only by a reference to the general work of Trevan and a somewhat outmoded paper by Coward and Burn. The reader is referred to a recent excellent paper by Emmens (published by the Medical Research Council of Great Britain) which might well serve as a model. The reviewer is rather insistent about this matter because he believes that future research on the physiological chemistry of androgens and oestrogens must involve accurate methods for their quantitation.

The section on hypophyseal hormones concerned with reproductive processes begins with Dr. Smith's careful, extremely readable account of the effects of pituitary ablation and its implantation. Dr. Fevold discourses eloquently on the follicle stimulating and luteinizing gonadotropic hormones. One is left with the impression that the dual hormone hypothesis, or any other hypothesis of the pituitary substances concerned in gonad stimulation, requires the final chemical evidence of pure substances for full substantiation. Dr. Engle's account of the gonadotropic substances of blood, urine and other body fluids is unexceptional. A clear differentiation is made between the various "pituitary-like" substances and order is made of a very disordered literature on their various physiological effects. Dr. Severinghaus' capable chapter on pituitary cytology attempts to relate the microscopic picture of cell changes in the anterior pituitary to functional effects of pituitary secretion. The correlations are fairly good, e.g. basophilic degranulation with clear evidence of gonadotropic secretion, but certain obvious lacunae should encourage the aspiring pituitary histophysiologicalist to further endeavour. In this connection there is unfortunate omission of any mention of the work of Dawson and his collaborators on the anterior pituitary "carminic cell."

Drs. Riddle and Bates conclude this section with an authoritative account of lactogenic anterior pituitary hormone.

The final section begins with Dr. Nelson's laudably critical examination of the putative rôle of the thymus and pineal glands in reproductive processes. He concludes that neither gland has much valid claim to being an endocrine organ. Dr. Mason's account of the rôle of the vitamins in sexual processes serves to indicate the paucity of our knowledge in this field. Of all the vitamins, E alone can now be held responsible for a rather specific rôle. Dr. Stone's chapter on "Sex Drive" brings the previous edition's account up to date with relatively little new information. It is surprising that this field has not been more fully exploited. The concluding chapter by Dr. Pratt on "Sex Functions in Man" brings one up with a shock, because it indicates that despite the previously detailed enormous advances in the sexual physiology of animals similar knowledge of man is either lacking or deficient. Dr. Pratt rightly points out that we are handicapped not merely by the unsuitability of man for certain experimental purposes, but even in those situations where valuable data might be forthcoming objective criteria are lacking. Thus the usefulness of various hormone preparations as medicines can scarcely be judged by data based on such imponderables as "improvement," "no relief," et cetera. It is unfortunate that the author himself presents a table instancing the equally "good" effect in relieving menopausal symptoms of the oestrogens, plain oil, phenobarbital, and other materials in which the effects are measured by exactly these scorned subjective criteria. The reviewer hopes that in future editions Dr. Pratt will be more liberal in his citations, e.g. in discussing the sex hormones and homo-sexuality he says "assays of urine for male and female hormone have shown . . . a disturbance of the normal balance," but no papers are cited.

"Sex and Internal Secretions" should be taken not merely as a handbook for the student and a lexicon for the scholar. It offers, as well, a basis for future investigation. In almost every chapter the as-yet-

unexplored is specifically indicated. If one were to dare to generalize, the major problem that invites exploitation is the mechanism of the action of the hormones whose qualitative effects are so well detailed. What might be called the "intimate biochemistry" of the reproductive processes is scarcely known. What the

hormones do is told well, but how they do it is still a large and open question. If this book were nothing else it would be invaluable as an incitement to the curious mind. But it is far from nothing else. It is, in fact, a remarkable contribution to knowledge in a vast, engaging realm of biology.

BRIEF NOTICES

EVOLUTION

THOUGHTS ON EVOLUTION. I. *Phases of Evolution. Anthropological Series of the Boston College Graduate School, Vol. IV, No. 1.*

By Joseph J. Williams, S.J. Boston College Press, Chestnut Hill, Mass. \$1.00. 9½ x 6½; 56; 1939 (paper).

This monograph presents, in a scholarly fashion, the different phases through which the theories on the origin of life and the process of organic evolution have passed since their inclusion into the realm of human thought. The present trend is held to be away from the practice of considering Darwinism and evolution as synonymous, and away from the hope of ever obtaining the environmental conditions necessary for the spontaneous generation, or the re-creation, of life. Darwin's theory of the origin of the species by means of natural selection is said to be only a small portion of the whole theory of evolution, inasmuch as it does not account for the origin of life or the divergence of forms down to the species. His theory of natural selection, or survival of the fittest, is attacked on the grounds that no scientific evidence is yet available which indicates that the fittest do survive, or conversely, that those which survive are the fittest. The thesis is closed with praise for Darwin's theory for the stimulus it furnished for further investigation in evolution, but with severe criticism for the dogmatic persistence of some scientists in clinging to popular authority without the necessary scientific evidence to support such a stand.

The volume is concluded by a long list of bibliographic references.

LEXICON OF GEOLOGIC NAMES OF THE UNITED STATES (INCLUDING ALASKA).

(Also includes the names and ages, but not the definitions, of the named geologic units of Canada, Mexico, the West Indies, Central America, and Hawaii). Part 1, A-L; Part 2, M-Z. U. S. Department of the Interior. Geological Survey. Bulletin 896.

Compiled by M. Grace Wilmarth. Government Printing Office, Washington, D. C. \$2.50 for the two volumes. 9½ x 5½; 2395; 1938 (paper).

This lexicon, compiled as a "time saver for the busy geologist" will be a valuable addition to any biological library and particularly to those where ecology and paleontology are special subjects. The definitions state, briefly, the lithology, thickness, age, underlying and overlying formations, and type locality.

In order to avoid undesirable duplication of names, and to supply information frequently sought, the names, geographic areas, and ages of the principal underground geologic units have been listed; also the names and geographic regions of Pleistocene moraines, with a reference to the publication in which an outline or a description of each will be found. The names of coal beds and ore beds have not been listed. The time terms have also been listed, but the full definitions of the era, system, and series terms having been given in United States Geological Survey Bulletin 769, 1925, only very brief definitions of them are given here, with a reference to Bulletin 769.

Stratigraphic charts "against which the definitions, redefinitions and geographic distribution of the units could be checked" have been prepared. They do not accompany the lexicon but we gather that they may be obtained from the U. S. Geological Survey.

GENETICS

ORIENTAMENTI DELLA MODERNA BIOLOGIA.
*Micromerismo od Organicismo? Mutazionismo
 o Lamarckismo?*

By Mario F. Canella. Nicola Zanichelli
 Editore, Bologna. 15 Lire. 9½ x 7;
 141; 1939 (paper).

In accordance with some of the philosophical views held by Bertalanffy, and accepting Raffaele's criticism of the gene theory, the author takes issue with the mutation theory of organic evolution. His arguments cover all the essential postulates of modern genetic theory. To begin with he is far from convinced about the characteristics and functions generally attributed to the genes and justifies his opinion by pointing out inconsistencies in the dicta of the geneticists themselves. But the author is mainly concerned with the mutation theory and he emphasizes that it implies, among other things, that chance mutations have brought about the transformation of Selachii into amphibia, amphibia into birds and mammals, anthropoids into Hominidae. In his opinion it is inconceivable, and there is no evidence whatsoever to show, that such a series of evolutionary changes could be the product of chance mutations. Consequently, he notes, mutation could possibly explain only the formation of varieties within the species. If this is so, he continues, it means that we must assume either that species are fixed and accept the existence of a Deity who has ordered the universe or else seek another explanation of evolution. The author believes that one has not far to seek since Lamarck furnishes the needed theoretical approach to the study of organic evolution. As an embryologist he finds in Lamarckism the theory that seems closer in agreement with the facts he has observed, and therefore he pleads for a better understanding of these principles, strongly chiding those who have gone out of their way to heap ridicule on Lamarck. In turn he becomes very sarcastic about the validity of the many experiments made to disprove the inheritance of acquired characters, pointing out that as planned they disregard the most important aspects of Lamarck's views. The author demonstrates a profound knowledge of the literature and a philo-

sophical ability of no mean value. Although not quite convincing he deserves attention as do all who criticize established dogmas.



YOU AND HEREDITY.

By Amram Scheinfeld, assisted in the
 genetic sections by Morton D. Schweitzer.
 Frederick A. Stokes Co., New York. \$3.75.
 8½ x 5½; xvii + 434 + 10 plates; 1938.

It might seem that nothing could be a farther cry from an exact science than fortune telling. Yet *You and Heredity* looks into the past, examines the present, and foretells the future. It is a genetics book written for the layman by a layman (who has read and consulted eminent authorities). In simple terms the mechanisms of heredity are revealed, and the significance of these findings in human lives is pointed out, at the same time shattering many age-old superstitions. Forecast tables are issued which enable one to predict future appearances and defects in himself and children on the basis of characteristics noted among ancestors or present relations.

Interesting sections tell of the inheritance of disease, mental traits, talents, and length of life. The closing chapters contain negative and positive eugenic measures which can be applied by society as a whole and by the individual for the betterment of his own life and the lives of his offspring.

By and large the author is careful to state only the facts of heredity and to label any doubtful points. However, he makes a few hidebound statements which have at one time or another exhibited leaks. Chief among these is the allegation that there can be absolutely no inheritance of acquired characters, whereas certain studies suggest the wisdom of less dogmatism on this point. All in all the volume is well written, containing a good index and a selection of useful references.



L'HYGIÈNE DE LA RACE. *Étude de Biologie
 Héritaire et de Normalisation de la Race.*
 By G. Banu. Masson et Cie, Paris;

M.O., *Imprimeria Natională, Bucharest*.
80 francs. 9½ x 6½; vii + 403 + 1
folding chart; 1939 (paper).

By the term "race hygiene" the author means the health and welfare of a national or ethnic group. In this volume he outlines the method of study that in his opinion is most apt to insure further progress in national well-being. As he states it, the main objective of research in race hygiene should be the investigation of all the controllable factors that can modify favorably or unfavorably the mental and physical qualities of future generations. From this statement it is obvious that the author stresses particularly the genetic aspect of human biology and in fact the greater part of the book is taken up by a discussion of the inheritance of physical and mental traits and the hereditary transmission of disease susceptibility. He notes that much more information is needed in genetics, but nevertheless he is a very strong advocate of the more extreme proposals made off and on by certain eugenicists. Numerous aspects of human biology are covered in this book since the author examines the demographic conditions of several countries relative to social hygiene and, in particular, to eugenic measures. The reader will find mentioned here a fair, even though limited, account of the work of European investigators in this field but very little regarding the contributions of American students of the subject.



ANGEWANDTE TIERZUCHT auf rassenbiologischen Grundlage.

By Carl Holecck-Holleschowitz. Verlag von Julius Springer, Vienna. RM. 12. (paper); RM. 13.50 (cloth). 10 x 7; xiv + 176; 1939.

This excellent treatise is concerned with the origin, development, and present-day methods in the breeding of domesticated animals in Europe. Dr. Holecck-Holleschowitz presents a description of the early European horse, cow, pig, sheep and goat, together with a summary of the effects of domestication and scientific breeding on the present day forms of

these animals. With the advent of genetics as a separate science has come a great advance in the development of specialized types of domestic stock. Pure strains of race- and dray-horses; of beef and milk cows; of wool- and meat-producing sheep; as well as wool-, meat-, and milk-producing goats have been developed as a result of the trend based on the principle of race biology. With the newer knowledge of animal genetics and animal nutrition, have come attempts to hybridize certain types of domestic animals so as to combine into one animal the valuable qualities of several pure strains, and it is of interest to note that these attempts have not been entirely without success.

The volume is illustrated by more than 100 photographs, and contains a 5-page table of contents.



LIFE PROCESSES IN GRAY NORWAY RATS DURING FOURTEEN YEARS IN CAPTIVITY. *The American Anatomical Memoirs* No. 17.

By Helen Dean King. Wistar Institute of Anatomy and Biology, Philadelphia. \$2.00. 10 x 6½; 72 + 2 plates; 1939 (paper).

Data for the eleventh to twenty-fifth generations are given in this second report on the studies of the changes in various life processes that take place in the *Rattus norvegicus* when bred in captivity for a number of generations (since 1919). Growth and variability in body weight, the reproductive period, the sex ratio, mortality, and mutations are some of the processes discussed in the text. The report on the first ten generations was published in 1929.

Plates of the hooded and curly mutants are given in the 1939 report. The hooded stock was developed by selective breeding; the curly mutation (a dominant mutation heretofore unknown in rats) was attributed to gene changes occurring in rats long bred in captivity. Other mutants are discussed in the text.

The late Dr. Donaldson's researches on organ changes in the fifteen generations (11-25) will be published later.

THE GENETICS OF GARDEN PLANTS. Second Edition.

By M. B. Crane and W. J. C. Lawrence.
With a Foreword by Sir Daniel Hall.
 The Macmillan Co., New York and London.
 \$3.25. 8½ x 5½; xxi + 287; 1938.

The first edition of this book (cf. Q.R.B., Vol. 10, p. 342) appeared in 1934. Since that time progress in genetics has been so great that many additions and occasional rewritings have been required to bring the subject matter up to date. The additions mainly consist of a discussion of linkage in *Zea mays*; multiple genes; genetics and cytology of *Iris* species; a chapter describing the chemical and genetical basis of flower color; a discussion of the genetics of melons; recent results of genetics of incompatibility in diploid and polyploid plants, etc.

**RECENT ADVANCES IN PLANT GENETICS.**
F. W. Sansome and J. Philp. Second Edition Revised and Rewritten.

By F. W. Sansome. *With Foreword by Sir A. Daniel Hall.* P. Blakiston's, Son and Co., Philadelphia. \$5.50. 7½ x 5½; xii + 412 + 8 plates; 1939.

In this second revision Chapters II, III and X have been extensively rewritten and others have been altered "in order to express the newer viewpoints of geneticists." A chapter on variegation and on chimaeras is included and there is a discussion of the more biological aspects of genetics, "since a common misconception that genetics is a conglomeration of cytological theories, statistical work and peculiar terminology is all too prevalent."

**GENERAL BIOLOGY****CONSERVATION IN THE UNITED STATES.**

By A. F. Gustafson, H. Ries, C. H. Guise and W. J. Hamilton, Jr. Comstock Publishing Co., Cornell Heights, Ithaca, N. Y. \$3.00. 9½ x 6½; xi + 445; 1939.

"It is the aim of this book to present the basic principles of conservation to the reader so that he may gain an understand-

ing of tomorrow's problems and be in a position to deal effectively with them."

All forms of conservation are considered: soil and water, forest, fish, game, and mineral resources. The authors do not take an alarmist attitude, but rather give a critical evaluation of the state of depletion as it now exists, the problems that confront us, and methods by which we can deal with these problems. Educated individuals, through public coöperation and wise use of the vote, may eventually do much for the cause championed by this volume.

**A BIOLOGY OF FAMILIAR THINGS.**

By George L. Bush, Allan Dickie and Ronald C. Runkle. American Book Co., New York. \$1.92. 8½ x 5½; [6] + 695; 1939.

Most high school students feel that the reading of any textbook is labor. This volume goes as far as possible in minimizing cut and dried facts, presenting, as it does, material which is of greatest interest to young folks, and demonstrating biological principles along the way. This is done by showing how biology applies to man in health and sickness and in the keeping of gardens and of household pets. The economic importance of plants and animals is stressed, with particular reference to the control of pests and to the problems of conservation. For better than average students numerous assignments and experiments are suggested. There are also extensive lists of references.

**DESERTS.**

By Gayle Pickwell. Whittlesey House, McGraw-Hill Book Co., New York and London. \$3.50. 11½ x 9; xiv + 174; 1939.

There is more plant and animal life in a desert than the average person usually suspects. This fact is brought very forcibly to one's attention by the beautiful photographs that illustrate this book. The author mentions the commoner plants and animals, typical of the deserts of the

Southwest, that spend their lives under rigorous conditions of existence, and explains how they are adapted to meet this struggle. But it is the illustrations that form the backbone of this work, the text being secondary, although interesting and essential.



OUR NATURAL RESOURCES AND THEIR CONSERVATION. Second Edition.

Edited by A. E. Parkins and J. R. Whistaker. John Wiley and Sons, New York; Chapman and Hall, London. \$4.00. 9 x 5½; xiv + 647; 1939.

This volume follows the same plan of the earlier issue (*cf.* Q.R.B., Vol. 12, No. 2). In this edition, however, the 23 contributors have been able to give greater consideration to cross references and to eliminate duplication of material. All statistics have been brought up to date so far as possible. Some chapters have been reworked to fit changing conditions, and a new chapter has been added on the conservation of commercial fish. The editors point out that the greatest advance in any phase of conservation is in recreation, which involves, of course, hunting and fishing.



MANUAL OF BIOLOGY. Part One, The Protozoa and the Plant; Part Two, The Metazoan Animals.

By Douglas Marsland with the collaboration of Paul F. Brandwein. Henry Holt and Co., New York. \$1.20 each. 11 x 8½; Part One, ix + 176; Part Two, ix + 211; 1939 (paper).

Part One of this laboratory manual contains 24 exercises for the study of protozoa and the plant, and the second part has 25 exercises for metazoan animals. Both parts have sections on the sources of teaching materials and the pronunciation and derivatives of biological terms. The plan for centering the work around organisms and types rather than according to principles of biology was the outgrowth of many experiments in teaching large groups of students at Washington Square College, New York University.

SIR JOSEPH BANKS ISLANDS. Part II. Reports of the McCoy Society for Field Investigation and Research. No. 3.

Proceedings of the Royal Society of Victoria, Vol. 51, Part 1; 143-186; 1939.

This pamphlet represents Part II of the report by the expedition of the McCoy Society for field investigation and research, and describes the geology, vegetation, mollusks and fish associated with the Sir Joseph Bank Islands. For the most part, the plant and animal forms are quite similar to those of the neighboring mainland of Australia, and the only new forms described are one genus and eight species of mollusks.



SOIL AND HUMAN HEALTH. A Call to Action.

By Edgar J. Saxon. C. W. Daniel Co., London. 3d. net. 8½ x 5½; 8; 1939 (paper).

This little paper presents the substance of an address given to the Nature Cure Conference at High Leigh, Hoddesdon, Herts, England. A list is given of the necessary requirements for "restoring, maintaining and measuring the health and fertility of England's soil, or of soil anywhere in the wide world."



COLLEGE BIOLOGY. Second Edition.

By Walter H. Wellhouse and George O. Hendrickson. F. S. Crofts and Co., New York. \$3.00. 8½ x 5½; viii + 391; 1939.

In the revision of this text (*cf.* Vol. 11, No. 4 for notice of first edition) corrections and changes, "taking advantage of the suggestions of students, teachers and other critics" have been made. A chapter on conservation has been added and the number of illustrations extended.



HUMAN BIOLOGY

ANCIENT ANDEAN LIFE.

By Edgar L. Hewett. Bobbs-Merrill Co., Indianapolis and New York. \$4.00. 9½ x

6½; 336 + 32 plates + 1 folding map; 1939.

This completes a popular trilogy on ancient life in America. *Ancient Life in the American Southwest* and *Ancient Life in Mexico and Central America* are the first two volumes in the series on the American Indian race and its vital place in the cultural history of man.

Ancient Andean Life is divided into three parts. Part I deals with the history of man as a world-drama and the earth as a stage with the following principal stage settings: (1) desert areas, (2) great river valleys, (3) coast lands and continental islands, (4) intermountain plateaus, and (5) sterile lands with no history. The author makes a distinction between culture and civilization and defines culture as "the result of man's acceptance of nature as he finds it, . . . —not seeking to become the master, but remaining the child of nature; at one with her in mode of life, in aspiration, in worship—in short, in every phase of existence." A general archaeological picture of the world is given in which the Andean world has its niche.

Part II deals with the stage settings of the Andean world and the description and history of the Andean Indians of the present time, Inca time, Pre-Inca time, and remote time. Particularly amusing is the author's treatment of the Jivaro Indians. These Indians have quite a reputation as head-hunters; they also have novel ways of dealing with enemies. The author tells of their method of satisfying the gold-hunger of a Spanish governor—melted gold was poured down his throat.

In Part III (Retrospection and Conclusion) the author tells of his experiences of forty years work in the trenches as a "dirt" archaeologist. It is here that he expresses his opinions on the present study of archaeology to the effect that less academic verbalizing on the part of the professors and more spade archaeology would make for more productive results. The author also writes of the great archaeologists of the nineteenth century whose work kept his own interest aflame. Lastly, he speaks of the aims and values of this science.

SHEBA'S DAUGHTERS. Being a Record of Travel in Southern Arabia.

By H. St. J. B. Philby. With an Appendix on the Rock Inscriptions by A. F. L. Beeston. Methuen and Co., London. 218. net. 9¼ x 6½; xix + 485 + 47 plates + 1 folding map; 1939.

Sheba's Daughters is the account of the author's travels in Southern Arabia. The greater part of his journey lay in the little-known, undemarcated, unexplored territory of South-West Arabia between Sa'udi Arabia and the Aden Protectorate. The author was the first European to enter Abha, the capital of Najran, that much disputed frontier region between Sa'udi Arabia and the Yaman. He was the second European to visit Shabwa, but the first to make a thorough study of this ancient capital city of the Himyarites, its inhabitants, and the famous ruins of the Temple of Astarte. The first European to have visited Shabwa was Hans Helfritz who arrived there late at night and hurriedly quitted the city in the first hour of daylight escorted by its enraged citizens and a good deal of gunfire.

Philby's book represents an enviable record of travels and amazing explorations in South-West Arabia. In addition, the state of unrest among the peoples of that part of Arabia which is south of Sa'udi Arabia is vividly set forth. British imperial ambitions coupled with the Muslim's ingrained love of independence have produced that unrest; the Muslim in South-West Arabia envies the peace of Sa'udi Arabia and wishes for the intervention of Ibn Sa'ud in the South. Especially in Hadhramaut is there an undercurrent of restlessness, and particularly here do the people look to the coming of the Wahhabi King to help maintain the peace and order which the Muslim people are unable to maintain.

At the close of the book there is an excellent detailed map of the author's route. There is also an inset diagram on the same map of the Ruins of Shabwa. Although there is an index to the textual material, unfortunately there is no index to the map which is very detailed and hard at times to follow. There is also an appendix by A. F. L. Beeston on the inscriptions found by the author in his travels. This appen-

dix is followed by a word-index to the inscriptions.

Many excellent photographic plates occur throughout the text.



A BOOK OF THE 'BOUNTY.' *William Bligh and Others.*

Edited by George Mackaness. J. M. Dent and Sons, London; E. P. Dutton and Co., New York. 90 cents. 6½ x 4½; xv + 326; 1938.

The editor of Everyman's Library has done an important service in making easily available a considerable part of the most pertinent original documents regarding one of the most remarkable experiences in the history of humankind. To the human biologist there is no facet of the Bounty episode that is not of enormous interest and deep significance. Naturally everyone who has told the story of what happened, from the time it happened down to the present when every schoolboy knows something about it from the movies, has colored his narrative to a greater or smaller degree with the pigments of his prejudices. The present volume gives Bligh's side of the story. And in accomplishing this it does something more. It makes it possible for us to form in some degree a first-hand independent judgment as to what sort of man Bligh really was. The conclusion seems inescapable that he was not essentially different in kind from the general run of British naval officers of his time. The system deliberately encouraged pomposity, cruelty, and graft in the officers at the expense of the men. A just conclusion would seem to be that Bligh was no more of a knave than his peers in the service, who were all permitted and indeed encouraged to make as much as they could out of the business of victualling and otherwise supplying their ships. But quantitatively he appears to have been vainer, more conceited, and less capable of administering wisely the enormous power over other human beings vested in a naval commander by the system of his time, than the average.

Every Bounty-story fan, and they must be legion, will want this volume.

THE SOCIAL FUNCTION OF SCIENCE.

By J. D. Bernal. The Macmillan Co., New York. \$3.50. 8½ x 5½; xvi + 482 + 2 folding charts; 1939.

The subject of this book is a very broad one. Generally speaking it intends to investigate the relation of science to modern society and the social and economic developments in our time. Or, as the author, a physicist at the University of London, states in his preface: "This book is an attempt to analyse this connection; to investigate how far scientists, individually and collectively, are responsible for this state of affairs, and to suggest what possible steps could be taken which would lead to a fruitful and not to a destructive utilization of science." The task is not an easy one and one must admire, at any rate, the enormous amount of material which has been collected by the author in order to give such an analysis in different fields of science and in different countries. There is first an instructive historical chapter, completed somewhat in a later chapter on international science in modern times. It deals with science in the older industrial countries of Europe, in the United States and in the Far East, science and Fascism, and science and Socialism. Perhaps the author overestimates somewhat here and elsewhere the development of science and its possibilities in Soviet Russia. Other chapters analyze the present organization of science in schools and universities, the training of the research worker, the efficiency of scientific research with many a criticism; again other parts deal with the application of science, difficulties in financing research, the effect of war preparations on science, scientific communication and the function of scientific publication. These are only some of the points treated in the book. It is well documented.



YOUR CITY.

By E. L. Thorndike. Harcourt, Brace and Company, New York. \$2.00. 8 x 5½; 204; 1939.

This book is intended to be a popular exposition of the author's investigation

on the General Goodness of Life in 310 communities and its measure or index G. The index G is the composite score of the well-being of a community and is derived from the rank held by the community relative to 37 items selected by the author. Among these items are included infant and typhoid death rates, numbers of telephones and automobiles, per capita expenditure for education and recreation, number of employed children, frequency of pauperism, the sale of certain magazines, and similar features about which some quantitative estimate can be made. The 37 items, given weights according to a criterion not explained here, were summed to arrive at a value of G which therefore appears to be more of a statistical pastiche than is the usual run of such indices. When the 310 cities are distributed according to the value of G the results show that Pasadena, Cal., Montclair, N. J., and Cleveland Heights, Ohio head the list while Columbus, Ga. and Charleston, N. C. are at the foot. The author proceeds then to correlate G with several other communal traits ranging from taxable wealth to the sex ratio of the population.

Incidentally, a number of the traits that the author correlates with G are already incorporated in G while others are implicit in some of the items that make up G. In the end, the analysis which certainly involves a tremendous amount of manual labor leads to results that, on the whole, are not very exciting and are pretty obvious to the intelligent reader, for whom this book is written.



REFUGEES. *The Annals of the American Academy of Political and Social Science, Volume 203.*

Edited by Francis J. Brown. *The American Academy of Political and Social Science, Philadelphia.* \$2.50 (cloth); \$2.00 (paper). 9½ x 6½; xv + 271; 1939.

Many well-known students of the social sciences have contributed to this number of *The Annals* dedicated to a discussion of the problems related to forced migration from one's country of birth or of residence.

The twenty-two articles included here concern four aspects of forced migration: (1) the social elements responsible for the phenomenon; (2) the characteristics of the contemporary groups of political exiles; (3) the types of situations faced by the refugees in the countries to which they have repaired; (4) the means of alleviating the hardships of the refugees. On the whole, the subject is discussed objectively and mostly from the standpoint of the historical forces involved in the past and present instances of forced migration. As is to be expected, however, the articles that deal with the German-Jewish migration of today are written in a style calculated to arouse further the sympathies of the reader. With such articles excepted, this series is instructive inasmuch as a feeble attempt has been made to examine the question of exiles and refugees from a correct perspective. It may be added that no practical workable solution of the present problem has been advanced. An annotated bibliography of some of the very recent works on the refugee problem is also found in this number.



THE RACES OF EUROPE.

By Carleton S. Coon. *The Macmillan Co., New York.* \$7.00. 9½ x 6½; xvi + 739 + 46 plates; 1939.

This work, prepared to serve as a college textbook of physical anthropology, is concerned with the origins of the peoples of Europe. Moreover, the book has been written to expound an hypothesis. This is that "the present races of Europe are derived from a blend of (A), food-producing peoples from Asia and Africa, of basically Mediterranean form, with (B), the descendants of interglacial and glacial food-gatherers, produced in turn by a blending of basic *Homo sapiens*, related to the remote ancestor of the Mediterraneans, with some non-sapiens species of general Neanderthaloid form." Such is the basic idea that colors the exposition of the material. The first six chapters are dedicated to a discussion of the skeletal remains of man from those of the Pleistocene period to those of the Iron age. The fol-

lowing chapters are concerned with brief descriptions of the peoples now living in Europe. In general the subject is presented in a lucid if compressed manner. Included in the book are maps, original photographs and an adequate bibliography. It cannot be said that the author has sufficiently demonstrated his thesis. But it has, however, about as much plausibility as many other of the hypotheses that have been advanced on the subject.



THE SOUTH AFRICAN DRAWINGS OF WILLIAM J. BURCHELL. *Volume One. The Bachapins of Litakun. Collotype Reproductions with Descriptive Text.*

Edited by Helen M. McKay. Witwatersrand University Press, Johannesburg. £. 2 12s. 6d. 14 x 10½; xv + 21 plates; 1938. William Burchell, naturalist and artist (1781-1863), visited Africa during the years 1810-1815. He made somewhat over 500 drawings and sketches during his travels. Some of these (20 colored plates and 96 vignettes) appeared in his work *Travels in the Interior of South Africa*, which was published in two volumes in 1822-24. The Gubbins Trust of Johannesburg has undertaken the task of publishing groups of drawings, together with the artist's notes, from the remaining collections and here we have the first volume—collotype reproductions (4 colored), mostly of the natives with whom Burchell lived—issued in a very fine limited edition. All but three of the 21 plates are portraits and

were made for the purpose of showing every variety of countenance and feature . . . some [subjects] having more resemblance to the Guinea Negro, and others, on the contrary, to the Hottentot or Kora, with whom there frequently exists a real consanguinity. . . . I was much struck with the little agreement which *their proportions* have with those of a European head. The relative position or distances of several features, differed often in a most remarkable degree; and the head of Mollémml would set all the rules of the art at defiance.

In his colored sketches the artist obtained the exact shades by preparing a kind of paint from *sibilo*, "a shining, powdery iron-ore of a steel-grey or blueish lustre"

with which the natives smeared themselves.



SIBERIAN MAN AND MAMMOTH.

By E. W. Pfizenmayer. Translated from the German by Muriel D. Simpson. Blackie and Son, London and Glasgow. 12s. 6d. net. 8½ x 5½; xii + 256 + 24 plates + 1 folding map; 1939.

This absorbing volume is an account of the author's two journeys into the far northeast section of Siberia. The expeditions were sponsored by the Russian Academy of Science and were made for the purpose of discovering and studying the frozen remains of the early Siberian mammoth, with nearly all the soft parts well preserved. These journeys took the author and his party through hitherto little known areas of the waste lands of northern Siberia, and the accounts of meeting with the inhabitants, and the study of their social and economic activities are quite as interesting as the description of the mammoth finds themselves. Two mammoths were studied *in situ*, and as far as possible, salvaged for further investigation. In addition to the study of the men and mammoths of this strange country, the author has included a discussion of the pertinent features of the climate, natural history, and the physical character of the terrain.

The work is well illustrated, completely indexed, and is concluded by Appendices I: The mammoth of Great Lyakhov Island; and II: The elks of North East Siberia.



SCHOOL AND COMMUNITY. *A Study of the Demographic and Economic Background of Education in the State of New York.*

By Julius B. Maller. The Regents' Inquiry, McGraw-Hill Book Co., New York and London. \$3.50. 8½ x 5½; xiii + 360; 1938.

"The primary aim of this study is to throw light on the relationship between the cost and the character of education in the various communities of New York State and to portray the demographic and socio-economic background of these communi-

tics." To this end a great many statistical and demographic data are given in the single chapters which deal with dynamics of population, school population, characteristics of the population such as density, occupational pattern, unemployment. Other chapters take into account social factors, economic background and many other things that have a bearing upon educational policy. The material is carefully selected and gives much useful information from different points of view. In the chapter on social factors, for instance, valuable data are presented on crime and delinquency, cultural factors such as illiteracy, library facilities and magazine circulation, as well as data on health conditions and general and specific death rates in different communities. Several appendix chapters give in greater detail tabulated data for the single communities.



MY DAYS OF STRENGTH. *An American Woman Doctor's Forty Years in China.*

By Anne Walter Fearn. Harper and Bros., New York and London. \$3.00. 8½ x 5½; xiii + 297 + 15 plates; 1939.

Dr. Fearn belonged to the earliest crop of medical women in this country. Born in the deep South with an ancestry of aristocratic attitudes, she got her medical education only over sharp family opposition. Soon after taking the M.D. degree a wholly unforeseen set of circumstances sent her out to China. She intended to stay only a year or so. Actually she stayed until a short time before her death, which occurred soon after this volume came off the press.

She was a woman of remarkable intelligence and executive ability, as well as a wise and skilful physician. These qualities, coupled with unusual charm and social *savoir faire*, combined to make a career as notable for its material success and the joys of living that it included as for the well-doing that made it blessed by the hosts of Chinese and Europeans she healed and helped. She married a devout missionary, but herself could always take her religion or leave it alone. Her private hospital in Shanghai (the Fearn Sana-

torium) appears to have been about as famous for its cocktails as for its medical services.

A notable book by a remarkable woman.



SEVEN LEAN YEARS.

By T. J. Wooster, Jr., and Ellen Winston. University of North Carolina Press, Chapel Hill, N. C. \$1.50. 8½ x 5½; xi + 187 + 16 plates; 1939.

This book deals primarily with rural problems during the years of the depression from 1931 through 1937. The authors have had access to a wealth of material concerning the distress of the rural classes which are bearing the burden of rearing and educating 31 per cent of the nation's children with only 9 per cent of the nation's income.

The improvement of rural life has been continuously agitated for many years. Country life commissions date back to the administration of Theodore Roosevelt, and farm aid has been the subject of countless investigations and organizations. Throughout this process the activities of the federal government in behalf of the farmer have increased, taking the form first of educational and advisory aid, then of the development of magnificent scientific bureaus and the extension service of the Department of Agriculture (p. 4).

However, not until the depression was the attention of the nation focused upon the importance of the rural situation. The single chapters give consideration to the manifold problems of the human elements involved as well as to the material side in terms of production and price structure.



RACE AGAINST MAN.

By Herbert J. Seligmann. Introduction by Franz Boas. G. P. Putnam's Sons, New York. \$2.75. 8½ x 5½; xii + 248; 1939. To the multitude of books which have appeared in the past five years propounding the folly of race definition another has been added. The author explains the impossibility inherent in any attempt to define race; traces man from his earliest progenitors; believes heredity to be a matter of fate; upholds the hybrid as an asset to the world in both the animal and

human spheres; shows that every type of man has been responsible for some measure of the world's ethical development; and finally blesses America for being the world's true melting pot. The volume, at first glance, seems to present its wealth of material in an unbiased manner, yet, on close surveillance, it is possible to detect an undercurrent of emotional distrust of the social and political trends of the Nazi and Fascist regimes in Europe. Or, to put the matter less delicately, realism compels us to say that this book is essentially counter-propaganda.



THE MENOMINI INDIANS OF WISCONSIN.
A Study of Three Centuries of Cultural Contact and Change. Memoirs of the American Philosophical Society. Volume X, 1939.

By Felix M. Keesing. University of Pennsylvania Press, Philadelphia. \$2.50.
9½ x 6; xi + 261 + 8 plates; 1939 (paper).

The author, in this monograph on the processes of cultural change, presents his research material covering three centuries (1634-1929) of cultural contact and change in the Menomini. The Menomini are one of the Central Algonquian tribes and as such represent "one sub-group within a great common area of culture and language found throughout the forest lands of the eastern and central parts of the United States and Canada." This monograph consists mainly of a survey of the ethnological and historical data concerning Menomini-white interaction during three centuries; the data are supplemented by the author's field investigations during a stay of over four months in the reservation community of the Menomini to observe the process of change as represented by the contemporary scene.

The author intends to visit the reservation again in order to bring fully up to date his study of contemporary life. This further study is made necessary in view of the adoption of the Indian Reorganization Act which aims at Indianization rather than assimilation.

GEORGIAN PORTRAITS.

By Percy Colson. *Williams and Norgate, London.* 8s. 6d. net. 8 x 5½; 269 + 12 plates; 1939.

Eleven biographical essays about persons prominent in the British scene, followed at the end by an autobiographical self-portrait. The subject of each essay is introduced by some one other than the author. Only three of the subjects have any particular relations with science: Sir James Jeans—and Colson is rather more interested in Jeans's musical talents and activities than in his science; H. G. Wells; and the Bishop of Birmingham, Dr. Barnes. The book is entertaining. The author's prose has great beauty and charm. He does not like Mr. Wells much—says his intelligence is "slick and superficial"—and gives him a thorough, if urbane, lambasting. The attitude towards men, events, and things is throughout a bit on the wistful side. The world is no longer as nice a place as it once was before the advent of "our ugly, modern, *soi-disant* civilization." But the dissatisfaction is never bitter. "To everything," says Colson, "there is a season—a time to be born and a time to die. I have had a good innings, and I have not the faintest desire to make my century."



LIFE'S JOURNEY THROUGH TIME. *An Approach to Some Problems of Human Biology.*

By Alex. S. Gillespie. *Pen-in-Hand Publishing Co., Oxford.* 5s. net. 7½ x 5½; 256 + 4 plates + 1 folding table; 1938.

In this book the author attempts to give schoolboys "something leading up to the biology of mankind," although the book is "especially concerned with population, war, and social problems." But isn't that rather too comprehensive for any volume of 200-odd pages, and isn't it asking a good deal of the understanding of almost any schoolboy or girl?

The book is divided into eight chapters, the first five of which discuss briefly the position of earth in space and the rise and spread of vertebrates culminating in the emergence of man and his rational mind. Chapter VI (pages 131 to 182) takes man

from the New Stone Age to the present. The two concluding chapters are "especially concerned with . . . social problems," for example, unemployment. There is a list of references for each chapter.



HOUSING REQUIREMENTS OF FARM FAMILIES IN THE UNITED STATES. U. S. Department of Agriculture. *Miscellaneous Publication No. 322.*

By Maud Wilson. Government Printing Office, Washington. 10 cents. 9½ x 5½; 39; 1939 (paper).

This is a useful report suggesting desirable features of comfort in farmhouses. It is based on opinions and facts sent in by many farm homemakers and deals with a good many constructive ideas toward better housing conditions. "Recent studies of farm housing indicate that only a small proportion of rural families in the United States live in houses that have most of the features desirable for family life." Some main points of the contents may give a better insight of the material treated: general requirements of farmhouses, construction and orientation, entrance protection, heating, sanitary facilities, storage facilities, provisions for child care, etc. The regional variations in housing requirements of farm families are treated in a special chapter describing the main differences in 14 regions of the United States.



THE BANTU TRIBES OF SOUTH AFRICA. Reproductions of Photographic Studies. Vol. III, Section 1, Plates I-XL. The Nguni. *Introductory Article on the Nguni* by N. J. Van Warmelo. *The Ciskei and Southern Transkei Tribes (Xhosa and Thembu)* by W. G. Bennie and a *Select Bibliography* by I. Schapera and W. G. Bennie.

By A. M. Duggan-Cronin. Deighton, Ball and Co., Cambridge. 25s. net. 11¼ x 8½; 57 + 40 plates; 1939 (paper).

Following a general discussion on the Nguni tribes, two sub-groups, Xhosa and

Thembu pictorially presented in 40 excellent plates, are considered culturally and historically in two separate brief reports. There is a large bibliography on the Xhosa and Thembu which is divided into the following two sections: (1) history, ethnography, and modern conditions and problems, and (2) language and literature. Photographic studies of other Nguni tribes will appear in future sections.



RASSENKUNDE UND RASSEN GESCHICHTE DER MENSCHHEIT. *Zweite umgearbeitete und erweiterte Auflage in zwei Bänden. Erster Band. Die Forschung am Menschen. Siebte Lieferung (Bogen 48-53).*

By Egon F. von Eickstedt. Ferdinand Enke Verlag, Stuttgart. RM. 7.50 (25 per cent less outside of Germany). 10¼ x 7; 96; 1939 (paper).

This number continues the discussion of the association of constitutional type with hormones, begun in the sixth *Lieferung* (cf. Vol. 14, No. 3), and begins the section on physiological group differences in man. As in previous numbers of this second edition, extensive revisions and additions have been made over the first edition. Numerous references are given.



VERHANDLUNGEN DER DEUTSCHEN GESELLSCHAFT FÜR RASSEN FORSCHUNG. *Band IX. Vorträge gehalten am 17. und 18. September 1937 auf der 9. Tagung in Tübingen. Sonderheft zum XV. Jahrgang des Anthropologischen Anzeigers.*

Edited by B. K. Schulz. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. RM. 22.80. 10 x 6½; [4] + 234 + 28 plates; 1938 (paper).

This volume contains a series of lectures given at the meeting in Tübingen on September 17 and 18, 1937. They deal with anthropology and morphology, newer results of chromosome research, twin studies, race history and some other items, predominantly from German material.

ZOOLOGY

THE PHYLUM CHORDATA. *Biology of Vertebrates and Their Kin. A Revision of Vertebrate Zoology.*

By H. H. Newman. The Macmillan Co., New York. \$3.60. $8\frac{1}{2} \times 5\frac{1}{2}$; xii + 477; 1939.

BIOLOGY OF THE VERTEBRATES. *A Comparative Study of Man and His Animal Allies. Revised Edition.*

By Herbert E. Walter. The Macmillan Co., New York. \$4.00. $8\frac{1}{2} \times 5\frac{1}{2}$; xxv + 882; 1939.

In this revision of *Vertebrate Zoology*, which appeared in 1920 and has had considerable usefulness for supplementary reading in comparative anatomy courses, it was necessary to produce an almost entirely new book in order to incorporate certain changes desired by the author. As it now stands, the book presents the subject matter of the lecture part of a course in comparative anatomy (the laboratory work, dealing with comparative anatomy, system by system, is independent of the lecture course) with considerable additional matter for supplementary reading. The lectures cover the whole Phylum Chordata, with emphasis upon the evolutionary history of the group, the interrelations of surviving groups, general principles illustrated by the group, and significant aspects of their natural history. The volume is illustrated by 235 figures and is well indexed.

The second of these excellent texts first appeared in 1928 (cf. Q. R. B., Vol. 3, No. 3). Since that time eleven reprintings have been made. It now appears in revised form and entirely rewritten. Ninety-three pages have been added and something over 80 illustrations, so that there are now 736 figures. An excellent index is provided.



ELEPHANTS IN AFRICA.

By Frank Melland. *Introduction by The Right Hon. The Earl of Onslow. Country Life, Ltd., London; Charles Scribner's Sons, New York.* \$3.75. $8\frac{1}{2} \times 5\frac{1}{2}$; xiii + 186; 1938.

A careful and rather critical book about African elephants by an intelligent sports-

man who has had a large amount of firsthand experience with them in the field. This is a book that every mammalogist will want to add to his library. The first five chapters deal with matters of behavior in general, and in particular with such things as mutual aid, seen in the other members of the herd helping a wounded comrade to escape. Chapters VI and VII deal with family life, breeding, childhood and adolescence. Two chapters (XII and XIII) are devoted to domestication, an important problem in Africa, on which real progress is being made. Other chapters are devoted to such topics as diet, control to prevent damage to crops etc., the degree of intelligence to be imputed to the elephant, native relations to elephants, and the much discussed mystery of sickness and death. On all these topics what the author has to say is restrained and sensible, great care being taken to make plain the distinction between what he knows of his own knowledge and what he has heard or read. Twelve full-page drawings by Stuart Tresilian add greatly to the charm of the book. There is a thorough index.

THE CHILDREN OF TANE. *Bird Life in New Zealand.*

By Mona Gordon. J. M. Dent and Sons, London; Whitcombe and Tombs, Christchurch, N. Z. 10s. 6d. net. $8\frac{1}{2} \times 5\frac{1}{2}$; xii + 250 + 8 plates; 1938.

This book gives the history of bird life in New Zealand, from the time that Aotearoa was a country covered by virgin timber until the present day when modern civilization has, as usual, completely altered the topography of the island and as a consequence has appreciably affected the bird life. Many of Tane's children have disappeared or have become scarce. Fortunately sanctuaries have been instituted for the protection of some of the rare and unique species. These refuges are all described in detail. Tieke, Tauhou, Kokako, Titipounamu, the Kiwi, and the Huia are some of the birds about which the author relates interesting facts concerning their habits. As may be gathered from the native names, the book is filled

with Maori bird mythology and also with much material on the Maoris themselves. There is an index, a few color illustrations of birds, some photographs of the island, and a list of the scientific names of the birds mentioned in the book.



PHYSIOLOGICAL GROUP DIFFERENTIATION IN LYMNAEA COLUMELLA. *The American Journal of Hygiene Monographic Series, No. 14.*

By Joshua L. Baily, Jr. *With a Foreword by Raymond Pearl. The Johns Hopkins Press, Baltimore.* \$1.00. 9 x 5 $\frac{1}{8}$; x + 133 + 2 folding tables + 2 plates; 1939.

Baily reports the results of an investigation on *Lymanaea columella* Say, the object of the inquiry being "to disclose the possibility of physiological races which were morphologically indistinguishable." He gathered two samples of snails, one from Centennial Lake, Fairmount Park, Pennsylvania and the other from a pond at Dumbarton, Maryland. These snails were bred under laboratory conditions and the longevity, mortality rate and fertility of the progeny were observed. The results of the investigation show that while the two groups of snails could not be differentiated morphologically yet they presented striking and significant differences relative to the physiological variables studied. The laboratory technique employed in this investigation is described in detail and the observations, also clearly presented, are accompanied by a brief but penetrating discussion regarding subspeciation and the formation of geographical races.



BATS.

By Glover M. Allen. *Harvard University Press, Cambridge.* \$4.00. 9 x 6; x + 368 + 30 plates; 1939.

There has long been a need for a good book about bats. Now we have it, and from the pen of a master. Allen has done a superb job, from both a literary as well as a scientific point of view. The bats are worthy of great biological respect for two primary reasons. They existed as "per-

fectly good" bats, not possibly to be mistaken for anything else, 20-25 million years ago in Eocene times. They represented then, as now, one of the most remarkable of all the adaptive divergences ever achieved by those remarkably adaptable creatures, the mammals.

The book is truly comprehensive. In its 21 chapters every aspect of the subject that arouses curiosity is authoritatively discussed. It is extensively and intelligently illustrated. It includes a bibliography of 14 pages. Altogether we cannot recommend this treatise too highly. It simply must be in every biological library.



BETWEEN PACIFIC TIDES. *An Account of the Habits and Habitats of Some Five Hundred of the Common, Conspicuous Seashore Invertebrates of the Pacific Coast Between Sitka, Alaska, and Northern Mexico.*

By Edward F. Ricketts and Jack Calvin. *Stanford University Press, Stanford University, Cal.; Oxford University Press, London.* \$6.00. 9 x 6 $\frac{1}{8}$; xxii + 320 + 46 plates; 1939.

The fascinating life of a seashore loses some of its complexity as one reads this lively account of what two scientists found along the Pacific Coast without the aid of even a pocket magnifying glass. Common names are used as much as possible to supplement the Latin ones, and descriptions of forms and habitats are in non-technical language. The many photographs and line drawings are a help to anyone wanting to identify his "catch."

About 500 common invertebrates of the west coast between Sitka, Alaska, and northern Mexico are discussed. The material is organized in such a way that the collector can run down his specimen from knowledge of its habitat alone, after all the easiest way for the beginner. An appendix gives references for the reader who wishes to go deeper into the field.



A LABORATORY INTRODUCTION TO ANIMAL ECOLOGY AND TAXONOMY. *A Laboratory*

Guide with Keys Prepared with Particular Reference to Fresh-Water and Terrestrial Habitats of the Deciduous Forest Region in North America.

By Orlando Park, W. C. Allee and V. E. Shelford. University of Chicago Press, Chicago. \$2.00. 8 x 5½; x + 269; 1939.

This laboratory course offers an extremely interesting and stimulating introductory plan of study of natural history for field and laboratory work. Preceding the exercises there is a comprehensive introductory discussion on the interrelationship of animals with their environment. The main part of the book is given over to exercises which have been so arranged that they involve field work, identification of field forms, observation and experiment, and reading and reflection. There are two synoptic keys—one to phyla and the other to classes and orders. These are followed by a glossary of the technical terms used in the keys. At the end of each exercise there is a list of suggested reading. There is also a separate alphabetically arranged bibliographical section. There are two indexes—taxonomic and subject.



THE RECENT MAMMALS OF IDAHO.

By William B. Davis. *The Caxton Printers, Caldwell, Idaho.* \$5.00. 9 x 6; 400; 1939.

This handsome volume describes the 141 different kinds of mammals to be found in Idaho. In addition to the account of species, there are chapters on the geography of the state, floral provinces, problems of distribution, and other matter pertinent to an understanding of the mammalian fauna with respect to its distribution, evolution, etc. The author has made a few systematic changes and described several new forms that will be of interest to the taxonomists. There are keys and distributional maps, a bibliography and an index. Also much material on life histories is given. So, all in all, this book represents a compendium of knowledge concerning mammals of this state and the surrounding territory. An altogether notable book.

ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Volume XXIV, Part 1, Numbers 1-5.*

New York Zoological Society, Zoological Park, New York. 85 cents. 10½ x 7; 63 + 8 plates; 1939 (paper).

The following papers are listed: (1) On *Sphyrion lumpi* (Krøyer), a copepod parasite of the redfish, *Sebastes marinus* (Linnaeus), with special reference to the host-parasite relationships; Ross F. Nigrelli and Frank E. Firth: (2) Notes on the functions of the forebrain in teleosts; R. G. Meader: (3) The Panama Canal as a passageway for fishes, with lists and remarks on the fishes and invertebrates observed; Samuel F. Hildebrand: (4) The cytology of the pituitary gland of two varieties of goldfish (*Carassius auratus* L.), with some reference to variable factors in the gland which may possibly be related to the different morphological types; Irving Levenstein: (5) Notes on plumage changes in the Quetzal; Lee S. Crandall.



OF ANTS AND MEN.

By Caryl P. Haskins. *Prentice-Hall, Inc., New York.* \$2.75. 9 x 6; vii + 244 + 15 plates; 1939.

The title of this book might give the impression that a comparison is made between man and ants but actually one finds very little of it. Instead, the book contains a delightful description, somewhat anthropomorphic in tone, of the social activities and probable social evolution of numerous genera of ants. Under such suggestive chapter headings as "Fascism or Communism?", "War," "Slavery," etc., the author limits himself in general to an account of certain aspects of the organization of ant society with but innocuous excursions into the parallels to be noted in human society.



✓ DOMESTIC PESTS. *What They are and How to Remove Them.*

By L. Hunter. Foreword by Winifred Cullis. John Bale, Sons and Curnow,

London. 7s. 6d. net. 8½ x 5½; xii + 235; 1938.

In this book is given, briefly, the essential information concerning all household pests, both animal and plant, that plague the British housewife. For each pest, the material has been arranged under headings (habits, life history, harm done, prevention, eradication, etc.), and is accompanied by excellent black and white figures which show various stages in life history. Simple remedies for eradication as well as what to use in serious infestations are always given. An excellent list of references accompanies the description of each pest and the volume concludes with a glossary and an index.



BUSCHI: *Vom Orang-Säugling zum Backenwölster.*

By Gustav Brandes. Verlagsbuchhandlung Quelle und Meyer, Leipzig. RM. 4.80; (25 percent less outside of Germany). 9 x 5½; [6] + 135; 1939.

This is the life history of Buschi, an orang-outang who grew from infancy to adulthood under the care and observation of Professor Brandes, former Director of the Dresden Zoological Gardens and famous authority on anthropoid apes. In addition to his research on the morphological and physiological development of orang-outangs and on the question of the connection between the human race and the highest anthropoid apes in the light of his researches, the author has presented a story which, though basically scientific in nature, will appeal to all animal lovers. There are many excellent photographs.



A GRAPHIC SUMMARY OF FARM ANIMALS AND ANIMAL PRODUCTS. (*Based largely on the Census of 1930 and 1935.*) U. S. Department of Agriculture. Miscellaneous Publication No. 269.

By O. E. Baker. Government Printing Office, Washington. 10 cents. 9½ x 5½; 88; 1939 (paper).

A presentation in graphic form of the number and value of the domestic animals and fowls and the honey-bee colonies of the United States as reported by the census of 1930 as well as by more recent special surveys. The value of the animal products (hides, beef, wool, milk, butter, cheese, eggs, honey, etc.) is discussed in relation to the fluctuations in the market due to changes in supply and demand.



JOURNAL DU CONSEIL. Vol. XIII, No. 3. Conseil Permanent International pour l'Exploration de la Mer.

Edited by E. S. Russell. Andr. Fred. Høst and Fils, Copenhagen. Annual subscription price 12 Kroner + Kr. 1.90 for mailing; single copies Kr. 4.50. 10 x 6½; 147; 1938.

Two articles on plankton ecology appear in this number, one discussing the relationship between zooplankton and phytoplankton, while the other considers diurnal variation in breeding and feeding. Further articles include quantitative estimation of phytoplankton, determination of fat in plankton and herring, migration of halibut, and the relationship between wind and current. The last half of the journal is devoted to reviews and current bibliography on marine subjects.



WHAT SNAKE IS THAT? *A Field Guide to the Snakes of the United States East of the Rocky Mountains.*

By Roger Conant and William Bridges. Drawings by Edmond Malnate. D. Appleton-Century Co., New York and London. \$2.00. 7½ x 5½; viii + 163 + 35 plates; 1939.

The identification of snakes east of the Rocky Mountains is the primary purpose of this book. The authors hope to foster young herpetologists' interest in the natural history of these vertebrates by providing the groundwork for their investigations. This field guide contains not only black and white illustrations of the snakes but also a few notes on their habits and range. There is a chapter

concerned with snake venom, a glossary, and an index.



ILLUSTRATED KEY TO WEST NORTH AMERICAN PELECYPOD GENERA.

By A. Myra Keen and Don L. Frizzell. Stanford University Press, Stanford University, Cal.; Oxford University Press, London. 75 cents. 11 x 8½; 28; 1939 (paper).

This key to Pelecypod genera of western North America is amply illustrated to facilitate ready identification. There is a glossary and an index, the latter including the authors of the various generic names and their synonyms. Malacologists will find this key a labor and time saving device for the identification of their specimens to the proper genus.



TYPENLEHRE UND UMWELTFORSCHUNG. Grundlegung einer idealistischen Biologie. Bios, Band IX.

By Friedrich Brock. Verlag von Johann Ambrosius Barth, Leipzig. RM. 4.20. 9½ x 6½; vii + 40; 1939 (paper).

The author, a pupil of Driesch and von Uexküll to whom he dedicates this treatise, discusses on the basis of the theory of von Uexküll and his own experimental investigations with the higher crustacea and *Buccinum undatum* the problem and methodology of an "idealistic" morphology. There are twelve illustrations and a bibliography.



BOTANY

THE WORLD OF PLANT LIFE.

By Clarence J. Hylander. The Macmillan Co., New York. \$7.50. 10½ x 7½; xxii + 722; 1939.

The author has written this book for the specific purpose of introducing the varied plant life of the United States to its citizens—the backyard gardeners, the windowbox gardeners, the countless community garden club members, the travelers, the college students who though familiar with microscopic work as pre-

sented in botany courses are unable to identify plant forms in the plant world about them, and the -ologists *ad infinitum* who see the whole of the plant world only in terms of their own specialties.

There is, in the United States, an assortment of plant life equalled by few other countries Because of the almost riotous abandon of American topography, from the mountains of the far west to the eastern coastal swamps, and from the flat mid-western plains to the desert basins of the southwest, there is every conceivable type of habitat with its own peculiar forms of plant life.

Although this book is a source of detailed information on the life of almost every common plant, both native and naturalized in this country, it is neither confusing nor tiresome to read. The author has followed a simple classification and has omitted as much as possible of the scientific terminology with which text books are so painfully swamped. In addition there are over 400 excellent photographs and line drawings.

There are two appendixes: The first is a detailed check list of species arranged by phyla, classes, orders and families with both common and scientific names given. Appendix II is a reference list of general literature, manuals and identification books, and books dealing with more detailed aspects of plant life—(these latter are correlated with the chapters). There is also a large and complete index.



INTRODUCTION TO THE BOTANY OF FIELD CROPS. South African Agricultural Series, Vol. 16. Vol. I., Cereals; Vol. II., Non-Cereals.

By J. M. Hector. Central News Agency, Ltd., Johannesburg; Gordon and Gotch, London. £3. 10s. net. 9½ x 6½; Vol. I. xi + 478 + xxxiv; Vol. II. vii + 479 - 1127 + xxxiii; [1938?].

Two important volumes for the student of botany, but more especially for the advanced worker in agronomy. The work is to be regarded as an "introduction" to this rapidly growing subject, bringing together a large amount of material, much of which can only be found in widely scattered sources. In spite of the size of the work, its scope is in breadth rather

than in detail. Nevertheless all the important phases in genetical analyses, cytology, physiology, etc., for each form are thoroughly discussed and wherever necessary details are included. "Crop ecology," a subject which the author feels is too vague at present for generalization, has been omitted.

The term 'field crops' is here used in a particulate sense: inclusively to incorporate all plants cultivated in the 'field,' *i.e.*, on arable land; exclusively to omit the plants of the garden, the orchard, the grove and the plantation. The distinction, however, is not absolute, since all 'cultivated' grasses are omitted and certain plants, such as cotton—regarded in certain areas as a 'plantation crop'—are included.

In the first volume the chapters are on the Gramineae—oat species (*Avena*), wheat species (*Triticum*), rye, barley, rice, millets, saccharum—the sugar canes—sorghums, and maize. The second volume is on the Liliaceae—onions and asparagus; the Moraceae—hemp and hops; the Polygonaceae—buckwheat family; the Chenopodiaceae—beet family; the Cruciferae; the Leguminosae; the Linaceae—flax; the Malvaceae—cottons; the Umbelliferae; the Convolvulaceae—sweet potato; the Solanaceae—potato, tomato, tobacco; the Cucurbitaceae; and the Compositae.



SHEEP AND TURNIPS: *Being the Life and Times of Arthur Young, F.R.S.*

By Amelia Defries. With a Preface by R. A. Butler and an Introduction by Montague Fordham. Methuen and Co., London. 7s. 6d. net. $7\frac{1}{2} \times 5\frac{1}{2}$; xviii + 235; 1938.

England's "Second Agrarian Revolution" of the late 18th and early 19th centuries laid the foundation for the England of well-tilled farms and fine livestock of today. Prominent among the men who did the spade-work of actual experimentation in agricultural methods and who helped formulate some of the legislation that encouraged good farming was Arthur Young, first Secretary to the Board of Agriculture. His interest, however, was not confined solely to agriculture. The broader aspects of a population's composition and the relation of the rural-urban

ratio to a nation's prosperity also claimed his attention. He was a strong advocate of a census, publishing a paper in 1770 entitled *Proposals for Numbering the People*. His papers, and the journal of his travels through England and France, are sources for much of the material here, to which the author has added a brief but comprehensive sketch of the background of England's agrarian revolutions. The present biography gives a well-rounded picture of this pre-Malthusian thinker, sometimes called "the father of modern agriculture."



WONDER PLANTS AND PLANT WONDERS.

By A. Hyatt Verrill. D. Appleton-Century Company, New York and London. \$3.00.

8 x 5 $\frac{1}{2}$; xiii + 296 + 16 plates; 1939.

A popularization that stresses the absolute necessity of plant life for the existence of all life on the earth, and describes the plant wonders used for food, clothing, shelter, beverages and other commodities, together with the plant giants, plant dwarfs, and other plant curios throughout the world. The reader is led on with the often repeated comment that curious as this plant may be, or valuable as that plant may be, the one about to be described is even more curious or more valuable than the preceding one.

The long bow is sometimes stretched to the breaking point. The statement that bacteria spores "... germinate and produce more bacteria even after being frozen in liquid air at a temperature of over four thousand degrees below zero ..." seems to overlook the fact that absolute zero is usually thought by physicists to be at 273° below zero Centigrade (-459°F.).

Journalistic science at not quite its highest level is about the right price tag for this volume.



BACTERIA the Smallest of Living Organisms.

By Ferdinand Cohn. Translated by Charles S. Dolley. Introduction by Morris C. Leikind. The Johns Hopkins Press, Baltimore. \$1.00. 10 x 7; 44; 1939.

It was indeed commendable to re-edit this

classical paper that takes an important place in the history of bacteriology. It was originally published in 1872 and as early as 1881 an English translation was made by Charles S. Dolley, then a medical student at the University of Pennsylvania, who had studied for some years abroad and at once recognized the importance of the paper. This edition of his translation has not been changed, except for the correction of some misspelled names, but the present editor has added to the text a fine introduction on the life of the original author as well as of the early translator. When Ferdinand Cohn published his essay in 1872 entitled *Ueber die Bacterien, die kleinsten lebenden Wesen*, Koch was still an unknown physician. The history of bacteriology, writes the new editor, has been written largely by medical men and the emphasis on the rôle of the bacteria as agents of disease has caused their importance in the life cycle to be forgotten. For this reason Cohn's paper is of importance since no one before or after him has so brilliantly and clearly indicated the position of bacteria in the general economy of nature.



THE GARDEN OF LARKSPURS. *With Decorations.*

By L. H. Bailey. The Macmillan Co., New York. \$3.00. $9\frac{1}{2} \times 6\frac{1}{8}$; viii + 116; 1939.

An important book for those interested in breeding and hybridizing larkspur. It belongs in the series which Dr. Bailey started sometime ago with *The Garden of Gourds* and followed up with *The Garden of Pinks*.

Information is given concerning soil, drainage, fertilizing and mulching, and location of beds necessary for the successful cultivation of larkspur. Aside from sections on the breeding and culture of delphinium, a key to significant species, and descriptions of species and varieties (113 varieties of 76 species), special attention is given to the following larkspur groups: Rocket, Forking, Bouquet, Garland, Candle and Red.

Leon H. Leonian contributes a chapter on diseases of delphinium and W. E.

Blauvelt on insects and other pests. There are also 23 black and white drawings in the text, a frontispiece and end-piece in color, and a useful index.



FLORAL MORPHOLOGY. *A New Outlook with special reference to the Interpretation of the Gynaeceum. Volume Two with additional illustrations and Index for Volume 1.*

By E. R. Saunders. W. Heffer and Sons, Cambridge. 10s. 6d. net. $7\frac{1}{2} \times 5$; xiv + 609 + vii; 1939.

Continuing the scheme begun in volume one (see review in Q. R. B. vol. 13, no. 1), the author discusses 151 additional families of flowering plants, again placing his emphasis on the relation of the vascular ground-plan to the floral ground-plan, and the importance of keeping this in mind when dealing with problems of floral morphology. There are many illustrations. An index covering both volumes is included.

An appendix contains a reproduction of the author's exhibit at a recent British Association for the Advancement of Science meeting. Under the title *A Century's Challenge to Orthodoxy* he presents a survey of the course taken by a point of view (the structural nature of the gynaeceum) which has been contrary to the traditional one. His citations extend from 1823 to 1923.



THE GROWTH AND NUTRITION OF WHITE PINE (*PINUS STROBUS* L.) SEEDLINGS IN CULTURES WITH VARYING NITROGEN, PHOSPHORUS, POTASSIUM AND CALCIUM: *with observations on the Relation of Seed Weight to Seedling Yield.* The Black Rock Forest Bulletin No. 9.

By Harold L. Mitchell. The Black Rock Forest, Cornwall-on-Hudson, New York. \$1.50. 9×6 ; vi + 135; 1939 (paper). This report, including 27 tables and 22 figures, gives in great detail the experimental procedure and results obtained in carefully controlled cultural experiments in white pine seedlings.

Seedlings grown in properly balanced nutrient-sand cultures are far superior, as regards total weight, balance between root and shoot and, to a lesser degree,

root development, than the average nursery-grown seedling of the same age. . . . The results of chemical analyses revealed an exceedingly high degree of correlation between the internal (seedling) content of N, P, K and Ca, expressed either as milligrams . . . or per cent of dry weight . . . and the external (solution) concentration of these elements.

These experiments were repeated in a series of field studies where all the nutrient elements, varied in the cultural experiments, were also varied individually and in several combinations. Only the more pertinent data from the field studies, however, are included in this report—in the section dealing with certain fundamental relationships.



EXPERIMENTS IN PLANT PHYSIOLOGY. *A Laboratory Textbook.*

By Walter E. Loomis and Charles A. Shull.
McGraw-Hill Book Co., New York and London. \$2.00. 9 x 6; xiv + 213; 1939.

This excellent laboratory manual is a revision of a portion of the authors' *Methods in Plant Physiology*, and is prepared especially for the use of beginning students. The problems are developed around the broad physiological processes in plants (growth, respiration, transpiration, photosynthesis, etc.), and are of such a variety as to meet the needs of numerous types of classes and courses. The manual does not supplement any particular text book, but rather gives a list of references for each of the chapter headings, as well as a list of general questions for each experiment.

The volume is well illustrated, both graphically and photographically, and contains a table of contents, a complete index, and an appendix listing numerous chemical solutions, formulae, preparations, and apparatus needed in the plant physiology laboratory.



ELEMENTS OF PLANT PATHOLOGY.

By Irving E. Melhus and George C. Kent.
The Macmillan Co., New York. \$4.00.
8½ x 5½; x + 493; 1939.

In the writing of this elementary text three points were kept in mind: (1) many students have no intention of becoming

professional plant pathologists but take the course as an aid to their work as farmers, teachers, or agriculturists, (2) the time allotted to the subject must be brief—not more than five hours for one quarter or four hours for one semester, (3) the availability of appropriate subject matter in sufficiently concise form. Emphasis is placed on parasitism in disease processes and the principles relating to control measures, coupled with the condensation and omission of unnecessary morphological and mycological data.

The volume is abundantly and well illustrated (259 figures) and contains a glossary, a list of 75 books dealing with some phase of plant pathology and a useful index.



CORRELATIONS BETWEEN ANNUAL PRECIPITATION AND THE YIELD OF SPRING WHEAT IN THE GREAT PLAINS. U. S. Department of Agriculture. Technical Bulletin No. 636.

By John S. Cole. Government Printing Office, Washington, D. C. 5 cents. 9½ x 5½; 40; 1938 (paper).

Data covering a total of 387 crop years at 19 field stations in the Great Plains are given of precipitation for the year ended July 31 and three indexes of yield of spring wheat. The primary study is made with an index of the average yields of about 30 plots representing low-, medium-, and high-yielding methods. Less detailed studies are made with the average yields of continuously cropped plots, a low-yielding method, and an average of yields on fallowed land, a high-yielding method.

The statistical data are arranged in 28 tables.



PLANT BIOLOGY. *An Outline of the Principles Underlying Plant Activity and Structure. Third Edition.*

By H. Godwin. The University Press, Cambridge; The Macmillan Co., New York.
\$2.25. 7½ x 5½; x + 308; 1939.

The Universities of Oxford, Cambridge, and London have combined "in the interests of schools, to make uniform the scope of teaching for the biology of their respective 1st M. B. examinations." For this reason, in the 3rd edition (the book

was at first intended mainly for first year medical students) there have been additions in certain sections and new chapters on the fern plant, and reproduction by means of the flower and the formation of seeds.



THE RELATIONSHIPS BETWEEN CUMULATIVE SOLAR RADIATION AND THE DRY WEIGHT INCREASE OF NURSERY-GROWN WHITE PINE AND RED PINE SEEDLINGS. *Black Rock Forest Papers, Vol. I, No. 13.*

By H. L. Mitchell and R. O. Rosendahl. *Black Rock Forest, Cornwall-on-Hudson, New York.* 11 x 8½; 87-94; 1939 (paper).

PRELIMINARY NOTES ON A METHOD FOR THE PREVENTION AND CONTROL OF WHITE GRUB INFESTATIONS IN NURSERY SOILS. *Black Rock Forest Papers, Vol. I, No. 14.*

By H. L. Mitchell. *Black Rock Forest, Cornwall-on-Hudson, New York.* 11 x 8½; 95-98; 1939 (paper).



MORPHOLOGY

RECHERCHES SUR L'EMBRYOLOGIE DU SYSTÈME NERVEUX CENTRAL DE L'HOMME.

By André Barbé. Preface by A. Souques. *Masson et Cie., Paris.* 250 francs. 10 x 6½; 1938 (paper).

This work embodies the results of three years of investigation on the development of the central nervous system in the human embryo. The first part is devoted to a detailed description of the nervous system of each of the 52 embryos, ranging in age from 18 to 252 days; the second, to a study of each region of the human nervous system in its development from the beginning to the end of pre-natal life. Some 320 excellent photographic illustrations have been included to supplement the text. No figure is included which is not thoroughly described; and likewise, no major point of interest is discussed in the text without the use of a photograph as a special aid.

M. Barbé, in giving a general plan of development for the human nervous system, has given particular and detailed attention to the cerebral vesicles during the first month of intra-uterine life; to the lateral and median ventricles; to the

development of the choroid plexus; to the formation of the anterior and posterior hypophysis; to the trapezoid area of His; to the cranial nerves (particularly the hypoglossal); and the spinal ganglia. The author gives a description of the primitive neural tube, and with the aid of several excellent figures, shows its two distinct (cephalic and spinal) portions. The cerebral region is quickly transformed into five divisions, or cerebral vesicles, which, Barbé finds, do not always develop along a longitudinal axis, but may follow three other distinct and separate patterns; namely, *apical*, *pontique* and *nuchale*. There have been found several morphological differences in the cerebral cortex not only from subject to subject, but even within the same individual. The variability of the date of appearance, the width and form of the fissures and grooves is of such magnitude as to make a generalization on the point impossible. One significant point in the work is that the fissure of Rolando, the appearance of which the classics place in the fifth month, has been found by M. Barbe to be clearly marked in several embryos in the third month of development.



FORM AND CAUSALITY IN EARLY DEVELOPMENT.

By Albert M. Dalcq. *The University Press, Cambridge; The Macmillan Co., New York.* \$3.50. 8½ x 5½; [7] + 197 + 2 plates; 1938.

This book is a monograph covering—as Professor Dalcq expressly warns us—his special views on the early organization of the egg, and on the causes, the mechanics, of development. Out of the abundance of available data, the author has chosen to present those embryological facts which to him suggest a general theory of organismal development.

Believing that "the causes [of development] cannot belong to any other category than the intimate physical and chemical nature of the germ materials, and their particular situation at the stage considered," and admitting that the nuclear factors have not yet been sufficiently analyzed, Dalcq feels that the cytoplasmic factors may now be defined in concrete

terms. He concludes that the material bases of germinal organization lie in a two-fold chemo-differentiation: first, in a "cortical field" (the dorso-ventral field of chordates, or its equivalent), and, second, in a "spatial gradient" (the yolk gradient of chordates, or its equivalent). Typically the former is a gradient of some substance dispersed mainly through the cortex of the egg, with its maximum concentration at the animal pole; the latter is a gradient of some substance dispersed more generally throughout the cytoplasm, but decreasing from the vegetative pole. The interaction between the "formative" or cortical field and the "differentiation" or "general activity" field provides the functional basis of morphogenesis. "In my opinion," writes Dalcq, "the organization of the egg—or of the sperm—prolongs that of the germ concealed in the parent soma. . . . The prime factors responsible for morphogenesis are contained in the germ, and not imposed on it from the outside."



ANATOMY OF THE HUMAN LYMPHATIC SYSTEM.

By H. Rouvière. Translated from the French by M. J. Tobias. Edwards Bros., Ann Arbor, Mich. \$4.00. 10 $\frac{1}{2}$ x 8 $\frac{1}{2}$; ix + 318; 1938.

This is the English translation of the painstaking and exhaustive work of Rouvière's *Anatomie des Lymphatiques de l'Homme* (cf. Q. R. B., vol. 7, no. 4). Many first-class drawings illustrate the work. Since the study of the lymphatic system is very often given too little attention in the medical schools as well as in most of the anatomic textbooks, the translation will find many friends among anatomists and clinicians. "In addition to completeness in anatomical descriptions of the lymphatic apparatus of the bodily organs," the translator writes in the introduction, "Professor Rouvière rarely overlooked an opportunity to direct attention to the regions where lymph nodes or lymphatics are intimately related to other organs or nerve trunks, and in many instances he has indicated the possible implications of such relationship."

THE BASIC MECHANICS OF HUMAN VISION.

By R. Brooks Simpkins. Chapman and Hall, London. 12s. 6d. net. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; viii + 228 + 8 plates; 1939.

This book will be of great interest to the experienced ophthalmologist who alone is able to prove the theories of the author. In particular he is of the opinion that the early prescription of glasses has a weakening effect on the eyes and especially that their employment by the increasing number of children is a serious menace to general health. More and more persons otherwise physically fit become dependent upon an artificial method of sight-augmentation when by proper exercising of the eye muscles sight deterioration, in the author's opinion, can be checked. The book is illustrated by many drawings showing the different stages and functions of the visual mechanism. It is well written and deserves to be carefully examined.



THE EMBRYOLOGY OF FLEAS. *Smithsonian Miscellaneous Collections. Volume 98, Number 3. (Publication 3527).*

By Edward L. Kessel. Smithsonian Institution, Washington. 45 cents. 9 $\frac{3}{8}$ x 6 $\frac{3}{8}$; 78 + 12 plates; 1939 (paper).

The author presents his researches on the heretofore little studied phase of the pulicine life cycle, namely, that of the embryological development. *Ctenocephalides felis* (Bouché) (the cat flea), *Nosopsyllus fasciatus* (Bosc.) (the common rat flea), and *Hystrihoposylla dipptiei* Roths (a giant form found in nests of the wood rat *Neotoma*) were selected as subjects for this study. Together the three families represented by the subject species contain over four-fifths of the total number of genera belonging to the order Siphonaptera.

The microtechnique used in this study is described in the first part of the monograph. At the end of the text are twelve excellent plates containing 90 figures. There is an extensive bibliography.



GROSS ANATOMY. *A Brief Systematic Presentation of the Macroscopic Structure of the Human Body.*

By A. Brazier Howell. D. Appleton-Century Co., New York and London. \$6.00. 9½ x 6½; vii + 403; 1939.

The decreasing amount of time allotted in medical schools to the study of gross anatomy has made it impossible for the student to assimilate all of the details. Voluminous texts and reference books increase the difficulty of sifting the trivial from the important. Howell's excellent condensation is an effort to overcome this handicap of the student. There is little consideration of physiology or histology, but necessary references are made to embryological derivation. Few illustrations are given, an anatomical atlas being a required adjunct. The volume contains a very complete and useful index.



CHORDATE ANATOMY.

By Herbert V. Neal and Herbert W. Rand. P. Blakiston's Son and Co., Philadelphia. \$3.50. 9 x 6; x + 467; 1939.

In essence this volume is a condensation of *Comparative Anatomy* (Q.R.B., vol. 12, no. 1) and contains the same excellent features of that work. However, the present material is such that it can be comfortably covered in the limited time allotted to comparative anatomy in the curriculum of the pre-professional student. It omits much of the detailed discussions of histology and embryology found in the earlier volume. This systematic study clearly describes and depicts the anatomical evidences of the evolution of the human body from lower forms.



FINGERPRINTS: *History, Law and Romance.*

By George W. Wilton. Foreword by Robert Heindl. William Hodge and Co., London, Edinburgh and Glasgow. 12s. 6d. net. 8½ x 5½; xix + 317 + 11 plates; 1938.

These pages tell an interesting history of dermatoglyphics. However, an undue amount of paper (half of the book) is used over the petty argument as to who first suggested fingerprints as a method of criminal detection. The author gives the laurel to Dr. Henry Faulds. A com-

plete survey is presented of fingerprint cases throughout the world. It is regrettable that so little space is devoted to the rôle of dermatoglyphics in anthropology.



ANATOMIE GÉNÉRALE. *Origines des Formes et des Structures Anatomiques.*

By H. Rouvière. Masson et Cie, Paris. 70 francs. 11½ x 7 ½; [4] + 192; 1938 (paper).

In this general anatomy the author stresses particularly the relation between the mechanics and the formation of the parts and organs of the body, and discusses, in some cases, modifications in the structure and their inheritance. Physicochemical influences are not treated in detail. The bibliography runs to 364 titles.



PHYSIOLOGY AND PATHOLOGY

PROTEIN METABOLISM IN THE PLANT.

By Albert C. Chibnall. Yale University Press, New Haven; Oxford University Press, London. \$4.00. 9 x 6; xiii + 306 + 3 plates; 1939.

This detailed and highly technical book makes its appeal principally to plant physiologists and biochemists. Excellent reviews and criticisms of historical and recent work on protein metabolism of seedlings mark the early chapters, the work of Schulze and Prianschnikow being particularly stressed. In regard to the formation of glutamine, the author concludes from experiments in his own laboratory that this substance can be produced in limited amounts by primary protein decomposition, and that glutamine and asparagine can also have a secondary origin. It is emphasized "that transfer of nitrogen from protein to amides does not necessarily imply that formation of these amides is exclusively a matter of protein metabolism."

One sees the agricultural value of this work in a chapter on the proteins of pasture plants. The quality of various types of pasturage, and seasonal variation in quality is shown in several experiments.

The value of protein analysis is well demonstrated in a discussion of the amount of cystine necessary in sheep forage to produce a high quality fleece.

The last part of the volume reviews studies on leaf metabolism and its regulation. Within a few hours after leaf detachment, protein decomposition can be detected. However, judgment is reserved as to the reason for such metabolism. Several appendices present methods of analysis of impure leaf-protein preparations. There are 370 bibliographic references.



LES GROUPE SANGUINS. *Leur Application à la Biologie, à la Médecine et au Droit.*

By Ludwik Hirszfeld. Translated from the Polish by Hanna Hirszfeld. Masson and Cie, Paris. 30 francs. 7½ x 5½; [4] + 169; 1938 (paper).

Professor Hirszfeld summarizes in this monograph the knowledge that has been acquired about blood-groups, particularly those aspects of the subject that pertain to practical problems of medicine, law, anthropology, and biology in general. The first two chapters are of an introductory nature and deal respectively with the physiological characteristics of the blood and with Mendelian inheritance. The author proceeds then to a more detailed examination of the subject and describes first of all the classification of blood-groups and their hereditary transmission. In the following chapters he discusses also in detail the significance of the observations made with reference to problems of establishing paternity, of detecting racial mixtures and of studying certain kinds of immunological reactions. The book closes with a chapter in which the author enumerates some of the problems which he believes are of great importance and deserve to be tackled immediately. Although there are available a number of good treatises on blood-groups, this is one of the most lucid and comprehensive expositions of the subject that has appeared to date. It reflects the author's long experience as one of the leading investigators in the field.

ANNUAL REVIEW OF PHYSIOLOGY. *Volume I.*

Edited by James M. Luck and Victor E. Hall. Annual Reviews, Inc., Stanford University P. O., Cal. \$5.00. 8½ x 6; vii + 705; 1939.

Undoubtedly the success attained by the *Annual Review of Biochemistry* (now in its eighth volume) has encouraged Dr. Luck and a group of physiologists to launch this annual. The members of the editorial committee are as follows: A. J. Carlson, J. F. Fulton, M. H. Jacobs, F. C. Mann and W. J. Meek. It is their hope

that this new Review will supplement the invaluable service which has been rendered for many years by *Physiological Reviews* and the *Ergebnisse der Physiologie*. We have not thought of publishing exhaustive treatments of selected topics such as may be found in these journals. The *Annual Review of Physiology* will have a somewhat different function and will be of value to the reader, not because of its depth of penetration into stated subjects, but because of its breadth, through year by year resums of the significant work in the entire field of physiology.

Twenty-four sections, written by well-known and authoritative investigators, treat such subjects as permeability, biological effects of radiation, growth, temperature regulation, physiology of the liver, blood, the spinal cord and reflex action, physiological psychology, kidney, etc. As in the *Review of Biochemistry* each section concludes with an extensive bibliography and the volume has both author and subject indexes.



YOU'RE THE DOCTOR.

By Victor Heiser. W. W. Norton and Co., New York. \$2.50. 8 x 5½; 300; 1939.

The author wisely emphasizes the fact that the material in this book is not meant to be a textbook to replace the physician. It is not for the ill, the lame, or the blind, but for those individuals who are not normally under a doctor's supervision. Dr. Heiser's experience in public health work in this country and in foreign nations has given him a broad perspective of living conditions and standards of health throughout the world, and based on this experience he now proffers a bookful of sensible suggestions for a healthier and happier life.

Half of the volume considers the troubles between man and his food, and since we are omnivorous creatures, there is plenty of material for discussion. There are very few *verboten*s and no one need fear after reading this entertaining volume that his life will be spent hereafter in utter discomfort wondering what would be the proper thing to do. Since the author himself is still quite hale and hearty, it will probably pay us all to follow his advice.



FIGHTING FOR LIFE.

By S. Josephine Baker. *The Macmillan Co., New York.* \$2.75. 8 $\frac{3}{4}$ x 5 $\frac{1}{2}$; [6] + 264 + 8 plates; 1939.

The theory and practice of child hygiene the world over is in a great measure due to the pioneering efforts of Dr. S. Josephine Baker. In this autobiography she has incorporated, in a delightfully readable manner, her experiences in (1) convincing her male colleagues that a hard-working woman has a place in the medical profession; and (2) in convincing this nation and the world that the most fruitful work in saving babies' lives is that which aims to prevent child diseases rather than that which aims to cure the pitifully diseased and half-dead forms of humanity. In the second undertaking, Dr. Baker inaugurated the principle of preventive medicine in child hygiene, with all its far reaching and fruitful results.

The volume is, in essence, the record of a free thinking American woman endowed with a conviction concerning her contribution to the world, and with the enthusiasm and persistence necessary for carrying that conviction to reality. The author's professional mode of thinking and her authoritative mode of writing have in no way been belittled by the spicy humor which adds so greatly to the interest of the book.



I. THE CENTER, THE GROUP UNDER OBSERVATION, SOURCES OF INFORMATION, AND STUDIES IN PROGRESS. *Studies From The Center for Research in Child Health and*

Development, School of Public Health, Harvard University. Monographs of the Society for Research in Child Development. Volume IV, No. 1 (Serial No. 20).

By Harold C. Stuart and Staff. *Society for Research in Child Development, National Research Council, Washington, D. C.* \$1.75. 9 x 6; xiv + 261; 1939 (paper).

This Center for Research in Child Health and Development was created some seven years ago mainly to provide the opportunity and material for investigation on the mental and physical development of children and on the factors bearing upon the phenomenon of growth. As the title indicates this monograph is the first of a series of publications from the Center and is concerned with its organization and method of operation. First of all, the growth of the children is measured and studied with the aid of anthropometric, orthopedic, roentgenographic and photographic techniques. The study of the factors influencing the growth is also approached from multiple angles since the inquiry concerns heredity, social and economic status, dietary habits and so on of the children. From the description given here it would seem that the investigation is conducted in the most ideal and thorough manner, and we look forward to the publication of the findings and results.



THE PATIENT AS A PERSON. *A Study of the Social Aspects of Illness.*

By G. Canby Robinson. *The Commonwealth Fund, New York; Oxford University Press, London.* \$3.00. 9 x 6; xiv + 423; 1939.

This book presents the results of an investigation carried on in the Johns Hopkins Hospital in 1936 and 1937, in which the clinical study of 174 patients in the medical wards and dispensary was supplemented by a study of the personal and social factors in each case. The material is presented in this book in the form of a brief abstract of the case history of each patient, including a discussion of the adverse social conditions found, and the effects on the medical status of the patient when the social condition was modified or the patient's attitude improved. The ab-

tracts are segregated into chapters under the following headings: patients with circulatory symptoms, respiratory symptoms, digestive symptoms, diabetes, syphilis and epilepsy, and psychoneuroses. The final chapter is devoted to a discussion of the importance of treating the patient as a whole. There is a bibliography of 28 titles, and an index.



PERSONAL AND COMMUNITY HEALTH.
Fifth Edition.

By C. E. Turner. *The C. V. Mosby Co., St. Louis.* \$3.00. $8\frac{1}{2} \times 5\frac{1}{2}$; 652 + 4 plates; 1939.

The present edition of this well-known college textbook on hygiene follows essentially the same order of exposition as that of the preceding ones. The author seeks to present a comprehensive picture of contemporary knowledge about individual and community health as well as the anatomical, physiological and general biological foundations on which this knowledge rests. The contents of this book therefore cover a wide field: the organ-systems and their function in health and disease, modes of infection and contagious diseases, personal hygiene and sanitation, and the several phases of public health work and administration. Although necessarily very sketchy in parts and written in a style that occasionally acquires an evangelical tone (*cf.* the discussion on alcohol), the book is more than adequate for its purpose. Each chapter ends with a short list of the more important publications on the subject treated.



LA MORT DES BRÛLÉS. Étude Expérimentale.

By Louis Christophe. Preface by Léon Binet. *Masson et Cie, Paris.* 40 francs. $9\frac{1}{2} \times 6\frac{1}{2}$; 95 + 20 folding charts + 9 plates; 1939 (paper).

Important experiments were performed by the author in an attempt toward the solution of the problem as to the processes causing death several days after injury from burns. Clinical and histological studies

were made both on dogs that had themselves been subjected to burns and those that had not been so injured but died after perfusion with blood from animals that had suffered a burn. The conclusion is that the toxic substance, although not sufficient to cause immediate death, is transmitted throughout the body by the blood stream, and when it reaches the brain causes injury to the vegetative centers, perhaps including the paraventricular and supraoptic nuclei of the anterior hypothalamus, from which the animals eventually die. The book is illustrated with photographs of apparatus and histological sections and tables showing the results of urine and blood tests on the experimental animals.



MEDICAL MICROBIOLOGY.

By Kenneth L. Burdon. *The Macmillan Co., New York.* \$4.50. $8\frac{1}{2} \times 5\frac{1}{2}$; xii + 763; 1939.

Since this book is intended primarily for the medical student beginning microbiology, the author stresses the clinical rather than the technical aspects of the science—the ward work rather than the laboratory side—though there are chapters on classification and on laboratory procedure.

The student who has just learned or is learning anatomy will be pleased to find infectious disease here treated in the same way, that is, by body systems. All infections of the skin, whether due to mite, rickettsia, or coccus, are discussed in one section, instead of being scattered through the text according to taxonomic relations. Insofar as possible the rest of the body is handled similarly.

The appendices contain laboratory methods, sources of information in the literature, and study questions.



SO YOU'RE GOING TO STOP SMOKING!

By J. C. Furnas. *Simon and Schuster, New York.* \$1.25. $7\frac{1}{2} \times 5$; vi + 97; 1939.

This amusing little book does not offer any sure-fire panacea for those who desire

to quit smoking "gasps" or other forms of tobacco. The author himself belongs to the ranks of those who have sworn off the coffin nails but finds himself still consuming them. However, good common sense remedies are proffered and several ways are suggested to fit individual tastes and inclinations. Truths and untruths concerning the tobacco habit have been separated and a consensus of present medical knowledge is given a chapter of its own. Most of the material has been gleaned from a questionnaire sent to famous people and from the invaluable experiences of the author himself. We recommend this entertaining volume to all and sundry, whether they be tobacco addicts or not.



THE PHYSIOLOGY AND PHARMACOLOGY OF THE PITUITARY BODY. *Volume II.*

By H. B. Van Dyke. *University of Chicago Press, Chicago.* \$4.50. 9 x 6; xiv + 402; 1939.

The present volume (for Vol. 1, cf. Q.R.B., Vol. 12, No. 3) begins where the first volume left off in 1935 and includes references to all important experimental work appearing in 1936 and 1937 and some 1938 reports. The author states that in the present volume "I have undertaken to meet the need of sifting and classifying the new data and concepts and of modifying the old by endeavoring critically to review recent work on the physiology and pharmacology of the pituitary body. A brief summary of my opinion of the present state of our knowledge has been added to each chapter." The material is arranged in ten chapters and in an appendix is a discussion of "The structural formulas and principal actions of hormones of natural origin." The bibliography (1,418 titles) represents 78 per cent of the articles which were considered.



MALARIA IN PANAMA. *The American Journal of Hygiene, Monographic Series, No. 13.* By James S. Simmons, with the collaboration of George R. Callender, Dalferes P.

Curry, Seymour C. Schwartz and Raymond Randall. *Johns Hopkins Press, Baltimore.* \$1.10 net. 9 x 6; xv + 326; 1939.

The subject matter is presented in three sections. The first, which is entitled "Malaria on the Isthmus of Panama (1501-1938)," includes two chapters, one of which deals with the history of the disease in this locality from the time of the early Spanish settlements until the beginning of the Panama Canal, and the other with its prevalence throughout the Republic of Panama up to the present time. Part two, entitled "Malaria in the Panama Canal Zone (1904-1938)," is divided into five special chapters and the third part, which is entitled "Malaria in the military forces of the Panama Canal Zone (1911-1938)," is composed of four chapters devoted to a general consideration of the malaria situation which confronts the United States Army.



THE NEWER KNOWLEDGE OF NUTRITION. *Fifth Edition Entirely Rewritten.*

By E. V. McCollum, Elsa Orent-Keiles and Harry G. Day. *The Macmillan Co., New York.* \$4.50. 8 $\frac{3}{8}$ x 5 $\frac{5}{8}$; ix + 701; 1939.

All those acquainted with previous editions of this important book will welcome its reappearance (the fourth edition has been out of print since 1935). It has been completely rewritten but there has been no change in the general plan of previous editions which represent

an attempt to interpret the meaning of the extensive experimental work relating to nutrition and described in numerous journals during recent years. Our purpose has been to present the subject matter in a form intelligible and useful to the large number of students, teachers, physicians, dentists, and others who are interested in being informed on the present knowledge of nutrition.



ANAIIS DA FACULDADE DE MEDICINA DE PORTO ALEGRE. *Ano I, Fascículo 1, Julho a Setembro de 1938. Publicação trimestral.* Universidade de Porto Alegre, Rio Grande do Sul, Brazil. 10 $\frac{1}{2}$ x 7 $\frac{1}{2}$; 303; 1938 (paper).

This is the inaugural number of the official organ for the publication of scientific investigations conducted in the Faculty of Medicine in Pôrto Alegre. It opens with a description of the school and a list of faculty members. The papers of greatest interest to biologists include discussions of hereditary diseases of the eye, by Corrêa Meyer; biotypology of the female, by Martim Gomes; modern aspects of criminology, by Celestino Prunes; new anatomical-physiological horizons in the circulation of the blood, by Guerra Blessmann. T. Mariente and M. Salis report a case of arterial hypertension and F. Ygartua a cranial tumor (Hand-Schüller-Christian's disease) in a two-and-a-half year old boy. The papers, published in Portuguese, are provided with English, French, or German summaries.



CHRONIC ARTHRITIS IN WILD MAMMALS. *Transactions of the American Philosophical Society. New Series, Volume XXXI.*

By Herbert Fox. *University of Pennsylvania Press, Philadelphia.* \$2.00. 11 $\frac{3}{4}$ x 9 $\frac{1}{4}$; 76 + 12 plates; 1939 (paper).

More than 1700 skeletal analyses and autopsies of wild animals have revealed that chronic arthritis is prevalent in nature. Those having the most conspicuous lesions were found to be the macrosomic animals, while small-bodied mammals, as the rodents and bats, were free of any symptoms.

Studies of this nature, it is hoped, will afford some clue to the yet baffling etiology of arthritis in man. There are twelve plates showing the affected skeletal parts, but no bibliography as all this material is practically unique.



THE WISDOM OF THE BODY. *Revised and Enlarged Edition.*

By Walter B. Cannon. *W. W. Norton and Co., New York.* \$3.50. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; 333; 1939.

Since 1932, when *The Wisdom of the Body* first appeared (cf. Q.R.B., Vol. 7, No. 3), much has been done in the experimental field which bears on the problems that

Dr. Cannon so ably and interestingly discussed in that volume. The present edition has been revised to include all new pertinent data. The general reader with a liking for science will find this even more absorbing than the earlier book while the student of biological problems cannot neglect a treatise which so clearly and soundly knits together the results of innumerable physiological experiments to give us a picture of the stability of the body as a whole and the means whereby that organization is maintained.



BIBLIOGRAPHY OF REFERENCES TO THE LITERATURE ON THE MINOR ELEMENTS AND THEIR RELATION TO PLANT AND ANIMAL NUTRITION. *Third Edition.*

Originally compiled by L. G. Willis. *Chilean Nitrate Educational Bureau, New York.* \$1.00. 11 x 8 $\frac{1}{2}$; [4] + 488; 1939 (paper).

An extremely useful reference book for the student of nutrition problems. The present edition has almost double the number of abstracts and references (4628) which the second edition had. Besides the increase in subject matter certain changes in the text have been made to make the bibliography more useful. Mr. L. G. Willis, soil chemist at the North Carolina Experiment Station, originally compiled the material (first edition appeared in 1935).



LE SÉRUM NORMAL. *Propriétés Physiologiques.*

By Denis Brocq-Rousseau and Gaston Roussel. *Masson et Cie, Paris.* 140 francs. 9 $\frac{3}{4}$ x 6 $\frac{1}{4}$; 630; 1939 (paper).

The authors have continued their thorough and critical compilation of observations made on the properties of the normal blood serum. The first volume of the series, published in 1934 (noticed in Q.R.B., Vol. 9, p. 373), dealt with the physical properties. The present one includes practically every study made on the physiology, the bibliography containing almost 4000 titles. It is planned to continue this valuable reference work

with a third volume to treat the diastasic properties of this serum.



BIOCHEMISTRY

CHEMIE UND PHYSIOLOGIE DES EIWESSES.

Edited by R. Otto, K. Felix and F. Laibach. Mit Unterstützung der Stadt Frankfurt a.M. Verlag von Theodor Steinkopff, Dresden and Leipzig. RM. 6.75. 9 1/2 x 6 1/2; xii + 203; 1938 (paper).

This volume contains the lectures, together with the general discussions following them, presented at the Third Frankfurt Conference for Collaboration in Medical and Natural Sciences. The lectures are divided into three groups. K. Felix, W. Dirscherl, H. Gremels, H. Bennhold, and Th. Wagner-Jauregg discuss the purely chemical aspects of albumen. E. Abderhalden, W. Weichardt, R. Prigge, R. Otto and K. Laubenheimer have contributed papers on the rôle of albumen in immunity reactions. Various aspects of the rôle of albumen in metabolism and nutrition, and the culture of plants with a high albumen content are treated by K. Wetzell, C. Schöpf, F. Laibach, H. Fink, R. von Sengbusch, W. Heupke, and K. Zorn. Author and subject indices have been added.



CRYSTALLINE ENZYMES. *The Chemistry of Pepsin, Trypsin, and Bacteriophage.*

By John H. Northrop. Columbia University Press, Morningside Heights, N. Y. \$3.00. 9 x 6 1/2; xv + 176; 1939.

The general chemistry of enzymes is presented early in the book, followed by chapters on the properties, activation, isolation, and tests for purity of pepsin, trypsin, chymo-trypsin and their inactive precursors. The bacteriophage, though never crystallized, exhibits experimental results similar to those of the active enzymes. An extensive appendix details methods of preparation and estimation of these substances.

LE PHOSPHORE DES VÉGÉTAUX. *Son rôle dans l'énergétique cellulaire. II. Phosphore Lipidique.*

By E. Michel-Durand. Presses Universitaires de France, Paris. 25 francs. 10 x 6 1/2; 84; 1939 (paper).

A continuation of the author's studies on plant phosphorus (*cf.* Q.R.B. vol. 14, no. 3). This section deals with the phosphatides (lipid P) and their derivatives in higher and lower plants, giving methods of extraction and physical and chemical properties. The formation, metabolism, and biological rôle of the phosphatides are adequately discussed.



TRAITÉ DE CHIMIE ORGANIQUE. Tome XIV. *Composés Azotés de l'Acide Carbonique. Composés Organoarséniés, Organophosphorés ou Organosilicés.*

By Ch. Courtot, J. Dœuvre, A. Guillaumin and F. S. Kipping. Published under the direction of V. Grignard, G. Dupont, R. Locquin and Paul Baud. Masson et Cie, Paris. 200 francs. 9 1/2 x 6 1/2; xix + 599; 1939.

This is the seventh volume of a 15 volume treatise to appear on organic chemistry. Like the preceding parts noticed in these columns, it maintains the high standards of scholarship of the work as a whole.



PROTEIN CHEMICAL STRUCTURE.

By Carl F. Krafft, 2510 Q Street, N.W., Washington, D. C. [4]; 1939.

ATOMIC OSCILLATORS.

By Carl F. Krafft, 2510 Q Street, N.W., Washington, D. C. [4]; 1939.

ORTHOHYDROGEN AND PARAHYDROGEN.

By Carl F. Krafft, 2510 Q Street, N.W., Washington, D. C. [2]; 1939.



SEX

CLASS FERTILITY TRENDS IN ENGLAND AND WALES 1876-1934.

By John W. Innes. Princeton University Press, Princeton. \$2.00. 9 x 6; xiii + 152; 1938.

After hundreds of articles and books have been written about the differences in the reproductivity of the socio-economic classes and some English and American writers, particularly, have gone so far as to see the downfall of civilization as a consequence of this phenomenon, it now appears that maybe in the near future such class differences as there are will be considerably diminished. This is the aspect of the problem that Innes has mainly investigated and discusses in this monograph. The first half of the book is concerned with a description of the trend of birth-rates in England and contains a painstaking reexamination of the 1911 British Census Report on marriage fertility. Rearranging the original data in several ways brings out nothing new and serves only to reinforce the previous conclusions. The second part of the book presents the results of what is practically a continuation of Heron's well-known study. The author examines for the period 1909-1934 the birth rates of the districts of London. The main findings are that during this period the birth-rates have declined in all the districts, those of the poor as well as of the rich. But, during the period of observation, the differences between the poor and rich districts have become less and less marked so that it would seem that there is manifest a tendency towards equalization of the reproductivity of the socio-economic classes. With restraint to be admired the author expresses such a conclusion in very cautious terms.



BIOMETRY

DEMOGRAPHICAL DATA, CLEVELAND, OHIO, 1931-1937.

By Howard W. Green. *Cleveland Health Council, 1001 Huron Road, Cleveland.*

\$1.00. 11 x 8½; [4] + 248; 1938 (paper).

INFANT MORTALITY AND ECONOMIC STATUS. *Cleveland Five-City Area 1919-1937.*

By Howard W. Green. *Cleveland Health Council, 1001 Huron Road, Cleveland.*

\$1.00. 11 x 8½; [6] + 123; 1939 (paper).

In the first of these reports, the author presents for each year from 1931 to 1937 the vital statistics of Cleveland, Ohio.

Following the order given by the U. S. Vital Statistics reports, the data included here concern general mortality, infant mortality and births. For some unexplained reason stillbirths have been omitted.

The second monograph is devoted to an interesting analysis of the trend in infant mortality as observed from 1919 to 1937 in 10 sections of Cleveland. These sections represent the subdivisions resulting from the ten-fold classification of the city area according to economic status. The findings, while not unique, bring into relief facts which have not always been given sufficient consideration. In the first place it is shown that the rate of decline in infant mortality has been higher in the poorer than in the richer districts. Secondly, it is observed that the neonatal (deaths under 1 month of age) mortality rate is about the same for all districts, independent of economic status, and has not altered significantly during the years from 1919 to 1937. The importance of this fact has never been sufficiently recognized although it has been pointed out by a number of investigators. Both publications give basic data of the kind that maybe some day will be available for all communities.



POPULATION AND FERTILITY.

By D. V. Glass and C. P. Blacker. *Population Investigation Committee, London.* 3s. 8½ x 5½; 101; 1939 (paper).

This booklet aims to inform the layman about the simpler and more common statistical methods employed to measure population fertility. It describes the basic data to be found in the vital statistics reports of various countries and discusses the additional information that would be desirable and useful to obtain. The authors have also included here the "age pyramid" of the populations of 12 countries and the recent figures regarding their population size, natality "reproduction rates" and world war dead (a very timely and instructive bit of information considering the present international situation). There is nothing contained in this work that is new to students of the

subject, but with respect to both contents and style the pamphlet well suits its purpose.



PRACTICAL ANTHROPOMETRY. Second Edition.

By Aloš Hrdlička. *Wistar Institute of Anatomy and Biology, Philadelphia.*

\$3.50. 10 x 7; xiv + 231; 1939.

The changes introduced in this second edition of Hrdlička's book consist mainly of the necessary additions to bring the book up to date. The description of the technique of measuring the living body has been amplified, sections on fingerprints and blood tests have been added as well as illustrative data on physical measurements. From its first publication Hrdlička's *Anthropometry* has been the standard textbook in most American institutions where physical anthropology is taught; therefore this second edition which does not substantially differ from the previous one will serve as well the purpose of teaching the art and principles of measuring the human body.



GRUNDBEGRIFFE UND HAUPTSÄTZE DER HÖHEREN MATHEMATIK insbesondere für Ingenieure und Naturforscher.

By Gerhard Kowalewski. *Verlag Walter de Gruyter and Co., Berlin.* RM. 5. 9 x 6½; 156; 1938.

The theory of determinants, vector analysis, limiting values, integral and differential calculus are all presented in this brief volume. Hence the treatment of each subject is necessarily limited. The author gives no applications of the material, confining his book to pure mathematics.



PSYCHOLOGY AND BEHAVIOR

PSYCHOLOGICAL FACTORS IN MARITAL HAPPINESS.

By Lewis M. Terman, assisted by Paul Buttenwieser, Leonard W. Ferguson, Winifred B. Johnson and Donald P. Wilson. *McGraw-Hill Book Co., New York and London.* \$4.00. 9 x 6; xiv + 474; 1938.

This book contains a detailed account of the observations made by the author and his associates on the married life and reactions of 792 couples. These couples are a selected group so far as concerns social, economic and educational status. They represent the higher and more articulate classes. About 10 per cent of the couples were obtained through family relations institutes and therefore are, in the majority, maritally maladjusted. The material consists of questionnaires filled out by the husbands and wives. An elaborate and clever scheme was developed in order to ascertain that the responses of the husband or the wife did not affect those of the other partner and in turn to assure the subjects that the answers would remain unidentified. The questionnaire dealt with some 400 items regarding (a) personality characteristics as measured with the Bernreuter and Strong tests; (b) expressions of opinion about the ideals of marriage; (c) feelings about the married life and spouses of the subject; (d) parents and childhood of the subjects; (e) the sexual habits and manifestations of the subjects. From such data was derived an index of marital happiness which is not above criticism, although not as unsatisfactory as an index of its kind usually is. The relation of marital happiness to the numerous single items of the questionnaire was then studied. As one follows the analysis it becomes evident that the author is not content to fit theory to observation but has some preconceived notion which he seeks to prove. This is that the personality factor is of great importance in marital relations while the sexual element plays only a secondary rôle. In this respect one notes the author's efforts to explain away results which apparently are as significant as those he accepts without hesitation. The value of the study is therefore considerably weakened. For the time being the only conclusion which can be drawn from the observations outlined is that all the factors contributing to marital happiness have not yet been identified.



LANGUAGE AND SPEECH HYGIENE. An Application of General Semantics. Outline

of a Course. *Monograph I. General Semantics Monographs.*

By Wendell Johnson. *Institute of General Semantics, 1234 East 56th St., Chicago.* \$1.50 (payable in advance). 10 $\frac{3}{4}$ x 8 $\frac{1}{2}$; v + 54; 1939 (paper).

This is a general outline and abstract of the course *Speech Hygiene* which was presented by the author at the University of Iowa in the summer of 1938. Dr. Johnson became interested in General Semantics after reading Count Korzybski's development of this subject. Especially interested was he in the application of general semantics to his own particular field, namely, the scientific investigation of stuttering.

The author first makes some introductory statements concerning the study of word-fact relations as a basic problem in general semantics, the meaning of the orientational adequacy of word-fact relations, and the important point that the study of word-fact relations is not concerned with words or facts as such but with the relations between them as made by human beings and the degree of agreement among individuals in word-fact relations. Various quantitative techniques for the measuring of the degree of agreement are then given.

The process of abstracting is next explained and a modified form of Korzybski's "structural differential" (a schematic diagram of the process of abstracting) is shown. Following a discussion of labels, descriptions and inferences, the author turns the attention of the reader to the study of remedial general semantics and its far-reaching fields of application.

A short alphabetical list of literature is appended.



PSYCHOLOGICAL METHODS OF HEALING.
An Introduction to Psychotherapy.

By William Brown. *University of London Press, London.* 7s. 6d. net. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; vii + 224; 1938.

This book is designed as an introduction to the subject of psychotherapy. Essentially, it is a *credo*, presenting the author's evaluation, after twenty-five years of clinical practice, of the tenets of various

European contributors to psychiatric thought, notably Freud, Jung, Adler, Janet, Charcot, Bernheim and Coue. No mention is made of American psychiatry. The chief psychotherapeutic procedures discussed are mental analysis, hypnosis, suggestion, autosuggestion and progressive relaxation, as they are used singly and in combination. There is very little discussion of the psychoses, and of the psychoneuroses, only hysteria, neurasthenia and compulsion neuroses are really considered. General problems of adolescence and maturity are covered in separate chapters. There is considerable philosophical digression, permeated throughout by the author's personal point of view.

As a text, the book seems unfortunate in its poor organization of subject matter, the incompleteness of its scope and the somewhat uncritical tendency to mingle opinion, conjecture and fact. There is a bibliography of 100 titles, and brief author and subject indices.



PERSONALITY DEVELOPMENT AND SOCIAL CONTROL IN TERMS OF CONSTITUTION AND CULTURE. *Three Lectures at The Tavistock Clinic, July 1937.*

By Ira S. Wile. *Oxford University Press, London, New York and Toronto.* \$1.25. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; [9] + 57; 1939 (paper).

This small book comprises three lectures delivered by Dr. Wile at the Tavistock Clinic in England. The first lecture entitled *Personality in Terms of Constitution*, is concerned with the general significance and meaning of constitution which is defined as "the aggregate of the physical and vital powers of an individual—physique or physical nature—also the aggregate of an individual's mental powers or qualities—temperament—or disposition." In the second lecture, *Personality in Relation to Culture*, the question of personal adjustments required in social living is discussed, and the various patterns of behavior which have been worked out for accomplishing this adjustment. The third lecture, *Social Control and the Prevention of Personality Disorders*, presents data on age, educational status, and vocational status in mental disease, and con-

siders various possibilities for social prophylaxis, religious, recreational, economic, etc. Dr. Wile concludes: "Social control should safeguard constitution by developing a more favorable culture."



THE PSYCHOLOGY OF MAKING LIFE INTERESTING.

By Wendell White. *The Macmillan Co.*, New York. \$2.50. 7½ x 5½; xv + 215; 1939.

This book is designed for the simple-minded layman with a sense of social failure, to whom all the successes he lacks are promised if he will only master the techniques herein outlined. These techniques comprise arousing curiosity, keeping up suspense, giving surprise, varying the voice and play of the features and varying the doing of things of every kind, a chapter being devoted to a detailed analysis of each. Having, by the application of these techniques, banished tedium and achieved his desired social goal, it should be possible for him to survey with equanimity the unwholesome behavior he has been spared, i.e. truancy, pyromania, alcoholism, gambling, etc. Many of the suggestions for furthering mental health put forward in the final chapters of the book are sound beyond controversy. A list of self-testing questions are appended.

There is little doubt but that the book will have a commercial success, and it is hoped that that of the readers will be as great.



THE MYSTERY OF THE BURIED CROSSES. A Narrative of Psychic Exploration.

By Hamlin Garland. *E. P. Dutton and Co.*, New York. \$3.75. 8½ x 5½; 351; 1939.

The author, through the aid of a medium, has been able to communicate with the spirits and has obtained their aid to locate crosses buried centuries ago by the Indians. There is still some mystery as to who buried them, but their location is real for wherever the spirits guided Mr. Garland and his cohorts, a cross was usually found

(usually, because spirits apparently can err like the rest of us mortals). We are astounded at the apparent ease with which one can communicate with such personages as Doyle, Kipling, *et al.* We can't understand why this method hasn't been used before to inquire about unfinished work from departed scientists, or maybe to locate the burial place of the missing link.

Affidavits, lists of witnesses, and photographs of ectoplasmic forms make this work one necessary of serious consideration for those interested in psychic phenomena.



THE LOGIC OF MODERN PSYCHOLOGY.

By Carroll C. Pratt. *The Macmillan Co.*, New York. \$2.00. 8½ x 5½; xvi + 185; 1939.

The impression received in reading this book is that it was written less with a view to influence the reader than to clarify the author's own thoughts on the subjects considered. The entire field of psychology is surveyed, the historical aspects, the points of views of different schools, and the different methodologies. The result is a re-evaluation of fundamental problems which, to this reviewer, seems somewhat academic, but which is understandable in the light of the author's attitude that

psychologists need more than any other group of scientists the protection of cloisters, an atmosphere of detachment and leisure. They can be most useful to society by staying in their laboratories and libraries, there to remain until they can come forth with reliable predictions and well-tested applications. Those who are in the midst of earthquakes and battles do not discover the laws of motion or the reasons why men fight.

There is an index, but no formal bibliography.



HEREDITARY AND ENVIRONMENTAL FACTORS IN THE CAUSATION OF MANIC-DEPRESSIVE PSYCHOSES AND DEMENTIA PRÆCOX.

By Horatio M. Pollock, Benjamin Malzberg and Raymond G. Fuller. *State Hospitals Press, Utica, N. Y.* \$2.50. 9½ x 6½; 473; 1939.

This thorough study was undertaken in 1928 by the New York State Department of Mental Hygiene and the State Charities Aid Association. The cases investigated include first admission to the Utica State Hospital in 1928, 1929 and 1930, and comprised 155 manic-depressive patients and 175 dementia praecox patients. Detailed analyses of the family and environmental history of those two groups of patients were made. The expectation of mental disease among the general population of New York State was taken as the norm. The general conclusion with regard to each psychotic group is reached that "we do not as yet possess any exact statistical theory of inheritance, capable of describing the transmission of mental disease from one generation to another. We do feel justified in concluding, however, that there is some generalized basis, accounting for a family predisposition." There is a full, pertinent bibliography and an index.



SCIENCE AND PSYCHICAL PHENOMENA.

By G. N. M. Tyrrell. *Harper and Bros.*, New York and London. \$3.75. 8½ x 5½; xv + 379; 1939.

The object of this book is to present what has been accomplished in the field of psychical research by strictly scientific method. Classical evidence, taken particularly from the records of the English Society for Psychical Research, is presented for the reader, as well as the interpretations which have been imposed. The subject-matter is presented in five parts: I. Spontaneous Extra-Sensory Perception, II. Experimental Extra-Sensory Perception, III. Significance of the Evidence, IV. The Mediumistic Trance and V. Theoretical Aspect of the Mediumistic Trance. The book is well written and the subject-matter receives as fair and comprehensive a handling as it is possible for a believer to give. However, to the critical reader the gap between evidence and interpretation will seem wide. In an appendix, the libraries throughout the world where the Proceedings of the English Society for Psychical Research may be found are listed.

ALFRED ADLER: THE MAN AND HIS WORK. *Triumph over the Inferiority Complex.*

By Hertha Orgler. With Foreword by O. H. Woodcock. C. W. Daniel Co., London. 8s. 6d. net. 8½ x 5½; 241; 1939.

This book by a close personal associate and devoted disciple of Dr. Adler, is divided into three parts. Part I, Adler's Development up to his Creation of Individual Psychology, presents personal data on Adler's life and a brief account of his break with Freud. In Part II, the tenets of Individual Psychology are discussed in a rather general way. Part III, the Application of Individual Psychology, is concerned with the importance of Adler's views for education and for psychotherapy. A chapter is devoted to describing the dissemination of Adler's views throughout Europe and the United States.

The book is written with more fervor than objectivity, and seems inadequate both as a biographical contribution and as a technical exposition. A complete bibliography of Adler's writings is appended.



THE SOLUTION OF MULTIPLE CHOICE PROBLEMS BY CHIMPANZEES. *Comparative Psychology Monographs. Volume 15, Number 3. Serial Number 75.*

By Kenneth W. Spence. *The Johns Hopkins Press, Baltimore.* \$1.00. 10 x 6½; 54; 1939 (paper).

By the simplification of previously used standard techniques in testing the behavioristic adaptation of chimpanzees, the author has been able to arrive at the analysis of the basis of solution of several problems of multiple choice, as well as the nature of the reaction tendencies exhibited prior to solution. With 17 chimpanzees whose ages ranged from 2 to 22 years, it was found that all solved the problems about equally well. The problems represented a graded series in difficulty, yet all were approached and solved by essentially the same behavioristic procedure. The relearning of a solution after an intervening period in which several other problems were solved, required only about one sixth the number of trials as the original learning period required.

HABIT CLINICS FOR CHILD GUIDANCE. U. S. Department of Labor. Bureau Publication No. 135. (Revised 1938).

By D. A. Thom. Government Printing Office, Washington, D. C. 15 cents. 9½ x 5½; iii + 97; 1939 (paper).



DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE MARCH OF MIND. *A Short History of Science.*

By F. Sherwood Taylor. The Macmillan Co., New York. \$3.00. 8½ x 5½; xiv + 320 + 14 plates; 1939.

This book could just as aptly be called "the development of the scientific method." In the opening chapters we see men struggling with magic to explain the natural world; then, further along, the scientist of the Middle Ages combats theology, and finally, championed by Da Vinci, Newton, Descartes and Darwin, the scientific method triumphs. In the author's words, "the religious man today is not troubled by a farrago of fables nor by the necessity of literal adherence to a book. If he finds the Kingdom of Heaven, it is within him."

Aside from a tendency to make theology the villain, the author has given a well-rounded picture of the growth of twentieth-century science, the changing attitude of men toward careful observation and experimentation. Eastern and Arabian science appears in its proper relation to European culture, instead of, as is more usually the case, being relegated to a few lines. In the later chapters, the histories of various specialties are told, for example, the study of sound, light, plant and animal physiology. The material, however, is general, and the appeal of the book should be wide. It is relatively non-technical.



SCIENCE IN PROGRESS.

Edited by George A. Baitsell. Foreword by Harlow Shapley. Yale University Press, New Haven; Oxford University Press, London. \$4.00. 9½ x 6½; xiii + 322; 1939.

This volume contains a series of lectures given in 1937 and 1938 at the Society of Sigma XI by some ranking scientists who describe here the results of their researches for a larger public. Thus reports are delivered on the latest progress in breaking down the atom (E. O. Lawrence); the separation of isotopes and their use in chemistry and biology (H. C. Urey); the recent advances in the study of viruses and virus diseases (W. M. Stanley and L. O. Kunkel); the functions of vitamins and hormones (K. E. Mason and R. R. Williams); and internal secretions in reproduction (Edgar Allen). There is another chapter on recent developments in our knowledge of chromosome structure (T. S. Painter); a new report on measuring electric potentials of the human brain (E. N. Harvey); and finally a review on animal metabolism: from mouse to elephant (Francis G. Benedict). The book closes with a list of references to each chapter, and an index.



SOMETHING SURPRISING.

By Gladys Adshead. Pictures by Helen Rinald. Oxford University Press, London, New York and Toronto. \$1.00. 6 x 7½; 69; 1939.

The author of this delightful little volume has shown a real talent for writing stories for children; stories which are scientifically correct and at the same time interesting and readable for the 8 to 12 year olds. In the 68 pages Miss Adshead has presented the drama of evolution from the formation of the earth, and the advent of life upon the earth down to the appearance of man as an intelligent and inventive animal. For those who are being introduced for the first time to the wonders of evolution, this little book will truly reveal "something surprising."

The line drawings by Miss Rinald will aid considerably in fixing in a child's mind the form of the plants and animals that have inhabited the earth through ages past.



UNDERSTANDING OUR ENVIRONMENT. *An Introduction to Science.*

By John C. Hessler and Henry C. Shoups.
Benj. H. Sanborn and Co., Chicago and
Boston. \$1.80. 8 x 5½; ix + 661; 1939.

This book is intended to develop in students of junior-high-school age a curiosity about the world around them. "General-science" topics of all types are discussed briefly and references to further reading given. The practical aspect of

science is stressed. Heat is considered from the standpoint of choosing the proper heating system for a building. The ideas of energy and friction, for example, are illustrated by the motion of a streamlined automobile.

There are 19 chapters divided into several problems, with study questions and notebook material for each.





THE PRICES OF BIOLOGICAL BOOKS IN 1939

By RAYMOND PEARL AND MAUD DEWITT PEARL

Department of Biology, School of Hygiene and Public Health, Johns Hopkins University

WHEN the QUARTERLY REVIEW OF BIOLOGY began publication in 1926 the custom was inaugurated of reporting at the end of each volume on the cost of the books that had been reviewed in its columns during the year. The present paper, therefore, is the fourteenth of these reports on the prices of biological books. The prices of foreign books have been converted into dollars on the basis of the exchange at the time the books were received. Table 1 shows the findings for 1939, arranged in the customary manner.

The total number of pages reviewed in 1939 is 179,601, an increase of 30,555 pages, or 20.5 per cent over 1938 and an increase of approximately 118 per cent over 1926, the year in which these tabulations began. In the fourteen years of the QUARTERLY REVIEW's history the books reviewed in these columns have aggregated a total of 1,804,265 pages. To American buyers these cost in the aggregate a total of \$19,300.09, leading to an average price per page for the total of 1.070 cents. The weighted average cost of 0.941 cents per page for all the books reviewed in 1939 is 13.2 per cent lower than that for all the books reviewed in our columns during the preceding thirteen years 1926-1938 inclusive, taken as a bulk total. It is even lower than the corresponding average for 1938 of 1.024 cents per page by 8.1 per cent. The 1939 average price per page for all books re-

viewed is 14.2 per cent lower than the corresponding figure for 1926, which was 1.097 cents. The general picture presented by the 1939 summary is clearly of a continuation of the lowered prices that began with the 1937 report. Furthermore, the rate of the decline in biological book prices seems to be accelerating. The American biologist buying books in 1939 got off quite easily, as compared with other years, so far as may be judged from our review samples. We make no prediction as to the further continuance of this sharp decline in prices. Such prophecy would be hazardous in any case, and particularly in the presence of another World War, in which the level of biological book prices will play no important part in either strategy or tactics.

In 1939 Germany stayed in her customary position at the head of Table 1, as the source of origin of highest prices for biological books. And, in general, all the sources of origin stood this year in about their usual order, except that the sample of British Government publications jumped up into a position actually above that of either British-American books or the books published in Great Britain by commercial publishers. The average price per page of German books was actually 6.9 percent *lower* in 1939 than in 1938. It is impossible to say whether this apparent lowering has any real significance, because of the sampling errors involved that cannot be precisely evaluated. But probably no one will fail to be impressed

by the fact that back some forty years ago, say, when German scholarship and *Kultur* generally did have a great, and on the whole beneficent, influence upon the intellectual life of the world, the general level of its book prices was not so widely

the absolute and relative changes in price from 1938 to 1939 and from 1930 to 1939.

The average prices per page of our samples of biological books from every origin except the British Government were *lower* this year than in 1938, by amounts ranging from about 2 per cent for books commercially produced in Great Britain to 32 per cent for the "Other countries" publications. But the average price of these "Other countries" books was still more than 52 per cent higher than ten years ago in 1930. British-American books, coming in direct competition with those published in the United States, continued and increased, both absolutely and relatively, the decline in average price noted last year. French books showed a decline in average price per page of 12.5 per cent in 1939 as compared with 1938, but was still up 34 per cent above 1930. The 1939 average price per page for biological books published commercially in the United States was over

TABLE 1
Prices of biological books, 1939

| ORIGIN | TOTAL PAGES | TOTAL COST | PRICES PER PAGE |
|--|-------------|------------|-----------------|
| | | | <i>cents</i> |
| Germany..... | 7,389 | \$159.40 | 2.16 |
| Other countries..... | 4,306 | 63.63 | 1.48 |
| British Government..... | 980 | 12.73 | 1.30 |
| British-American.... | 15,757 | 172.70 | 1.10 |
| Great Britain..... | 16,470 | 167.76 | 1.02 |
| United States..... | 116,068 | 1,041.14 | 0.90 |
| France..... | 9,709 | 60.91 | 0.63 |
| U. S. Government.. | 8,922 | 12.39 | 0.14 |
| Totals and weighted average, 1939.... | 179,601 | 1,690.66 | 0.941 |
| Totals and weighted average, 1926-1938 incl..... | 1,624,664 | 17,609.43 | 1.084 |

TABLE 2
Comparison of the prices of biological books for the decade from 1930 to 1939

| ORIGIN | AVERAGE PRICE PER PAGE | | | | | | | | | | CHANGE + OR - FROM 1938 TO 1939 | | CHANGE + OR - FROM 1930 TO 1939 | |
|------------------------|------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------------------------------|-----------------|---------------------------------------|-----------------|
| | 1930 | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | Absolute | Relative | Absolute | Relative |
| | <i>cents</i> | <i>cents</i> | <i>cents</i> | <i>cents</i> | <i>cents</i> | <i>cents</i> | <i>cents</i> | <i>cents</i> | <i>cents</i> | <i>cents</i> | <i>cents</i> | <i>per cent</i> | <i>cents</i> | <i>per cent</i> |
| British-American..... | 1.91 | 2.27 | 1.48 | 1.29 | 1.45 | 1.53 | 1.81 | 1.44 | 1.16 | 1.10 | -0.06 | -5.2 | -0.81 | -42.4 |
| Other countries..... | 0.97 | 1.53 | 1.02 | 0.85 | 0.86 | 1.20 | 2.26 | 0.86 | 2.18 | 1.48 | -0.70 | -32.1 | +0.51 | +56.2 |
| Great Britain..... | 1.13 | 1.19 | 0.89 | 0.66 | 0.96 | 0.84 | 0.94 | 1.27 | 1.04 | 1.02 | -0.02 | -1.9 | -0.11 | -9.7 |
| United States..... | 1.09 | 1.05 | 1.00 | 1.02 | 0.93 | 0.90 | 1.03 | 0.93 | 0.96 | 0.90 | -0.06 | -6.3 | -0.19 | -17.4 |
| Germany..... | 1.82 | 1.75 | 1.60 | 1.43 | 1.89 | 2.04 | 1.84 | 1.95 | 2.32 | 2.16 | -0.16 | -6.9 | +0.34 | +18.7 |
| British Government.... | 1.19 | 1.03 | 1.45 | 1.39 | 0.89 | 0.50 | 1.62 | 0.34 | 0.45 | 1.30 | +0.85 | +188.9 | +0.11 | +9.2 |
| France..... | 0.47 | 0.69 | 0.60 | 0.74 | 1.00 | 0.86 | 1.05 | 0.85 | 0.72 | 0.63 | -0.09 | -12.5 | +0.16 | +34.0 |
| U. S. Government..... | 0.30 | 0.28 | 0.36 | 0.17 | 0.18 | 0.11 | 0.21 | 0.16 | 0.17 | 0.14 | -0.03 | -17.6 | -0.16 | -53.3 |

disparate from that of other countries as it has been during the last 15 years.

Following the custom inaugurated some years ago Table 2 shows the price trends of books published in various countries during the decade from 1930 to 1939 and

6 per cent lower than the 1938 price, and more than 17 per cent lower than in 1930. The United States Government still continues to disseminate scientific information at a price to the consumer well below any other source known to us. In 1939

the average price per page was 17.6 per cent lower in 1939 than in 1938, and over 53 per cent lower than in 1930. American biologists, of course, pay their due share of the taxes that make this beneficence possible, in last analysis. But, in all fairness, it is probable that most of them will feel that the part of their tax dollar that is spent in this way is much more

TABLE 3

*Average biological book prices over the fourteen year period,
1926-1939 inclusive*

| ORIGIN | TOTAL PAGES | AVERAGE PRICE PER PAGE |
|-------------------------------|----------------|---------------------------------|
| | | <i>cents</i> |
| Germany..... | 180,357 | 1.643 |
| British-American..... | 130,523 | 1.502 |
| Other countries..... | 56,617 | 1.377 |
| Great Britain..... | 150,016 | 1.026 |
| United States..... | 1,074,598 | 1.009 |
| British Government..... | 10,199 | 0.948 |
| France..... | 142,561 | 0.692 |
| U. S. Government..... | 59,394 | 0.213 |
| Total and weighted average... | 1,804,265 | 1.070 |

usefully and wisely spent than a lot of the rest of it.

Table 3 sums up the whole fourteen years experience of the QUARTERLY REVIEW.

It is evident, from what has now grown to be a substantial sample, that during the past fourteen years biological books from all over the world taken together have averaged to cost the American

biologist very close to a cent a page, taking good, bad, and indifferent together. Furthermore it is plain that the sources of origin of these books fall into three fairly sharply defined groups relative to unit prices to the American buyer. In the first or relatively high priced group fall books in the British-American, Germany and "Other countries" categories of origin. The primary reason why the British-American books fall in this category is because they carry an import duty charge, paid on the sheets manufactured in England but issued here by an American branch house. The next or medium priced group includes the United States, British Government, and Great Britain (commercial publishers). None of the books in this category carry import duty charges in the prices here tabulated, because in the case of the British books the English prices are used. Actually an American buying these books would have to pay duty. This would then, in fact, throw them into the same group as the British-American publications. Finally the third or relatively low price group includes books published in France and by the U. S. Government.

The reader should bear in mind that these reports are based on small samples of books in general and, for some countries, on small samples of the biological books published. He should therefore be cautious in applying conclusions drawn from this material to the general domain of book prices.



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